TECHNICAL BULLETIN No. 10 MARCH, 1950

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FOREWORD

Between the years 1862 and 1915, rice constituted one of the chief agricultural crops of the Hawaiian Islands and was exported to California, British Columbia, and the Antipodes. Now (1949) the cultivation of rice is confined to a relatively small area (about 160 acres) on the island of Kauai and none is exported. In fact the entire crop produced in Hawaii in 1948 would be sufficient for only a 3-day supply of rice for all the Islands.

More than half the people of Hawaii are of racial stocks that use rice as a staple and basic food. The per capita consumption of rice by these groups ranges from 200 to more than 300 pounds per year (based on family diet studies), while the per capita consumption for all the people in the Islands is calculated to be 120 pounds per year. These figures indicate that Hawaii is one of the great rice-consuming areas of the world. The total weight of raw rice (largely white and highly milled) used in Hawaii exceeds that of any other single food. Consequently, even if rice is not an important agricultural commodity in Hawaii, its extensive and widespread use makes its nutritive value a major concern for those interested in foods used by the island people and justifies time and money spent investigating problems relating to its nutritive value and consumption. Such studies should provide us with more information regarding the keeping qualities of different kinds of rice, acceptability by rice-eating people, and basic data on nutritive values.

While providing us with some new data, the work here suggests the need for continued investigation of brown and processed rices as foods superior in nutritive value to white rice. Typical brown rice imported into Hawaii has a high thiamine content but a relatively low crude fiber content (0.60 percent, raw basis) and its digestibility should be compared with that of white rice.

If processed rice can be treated and milled so as to retain more of the vitamins and more of the physical characteristics desired by the rice eaters, and if brown rice can be stabilized to increase its keeping qualities, these two types will prove more acceptable substitutes for white rice.

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CONTENTS

PAGE

TABLES

FIGURES

INTRODUCTION

The people of Oriental ancestry living in Hawaii have adopted many western foods but they continue to use rice rather than bread as their basic cereal food. Caucasians born and reared in the Islands are also fond of rice and eat much more of it than the average mainlander. Data to be presented in this bulletin indicate that in 76 percent of Honolulu homes rice is served once a day or oftener. More than 5 million pounds are imported into the Territory monthly. Previous studies at this University (*47, 57*) have reported the yearly per capita consumption of rice in Japanese families to be 206–251 pounds.

The nutritive value of rice and the quality of the high rice diet therefore are of great public health importance. Although brown[1] rice is occasionally on the market, the overwhelming preference has been for white rice. In Oriental countries the use of white[2] rice has been a sign of higher economic and social status, only poorer people using brown or partially polished rice. Chinese, Japanese, Korean, and Filipino immigrants found they could afford highly polished white rice when they came to Hawaii. Merchants willingly complied with the demand for white rice because it is a product which stores well and is not subject to rancidity and insect infestation, as is brown rice. Because of the few requests for brown rice, the grocer was reluctant to stock it; the consumer, told over and over again that the store did not carry brown rice, ceased asking for it and thus further lessened the demand. These factors have combined to make the use of white rice habitual. People generally eat an accustomed food and so they continue to eat white rice and resist any suggestion that they change to brown.

Miller (*47*) in studying the dietary of 44 Japanese families in Hawaii found no serious deficiency of calories, protein, phosphorus, or iron except for a few families, but calcium was deficient in all but a few. The vitamin A and B contents of the diets were not determined, but on the basis of the kinds of food used, the diets were judged to contain inadequate amounts of these vitamins. Potgieter (*56*), in studying the nutritive adequacy of diets of rural families, concluded that diets of the 64 Japanese families studied were adequate in calories, protein, phosphorus, iron, and vitamin C; but calcium and vitamin A and B intakes were 34 to 64 percent lower than the recommended daily allowance.

The inadequacy of many high white rice diets is further emphasized by the record of beriberi deaths in the Territory. The 25 fatal cases of beriberi in the past 5 years have all been Orientals, 21 of them Filipinos, who are the racial group newest in the Islands and the ones who eat rice most often (see Figure 3, page 48). If so many deaths result from beriberi, there must be many sub-clinical cases. The problem of adequate thiamine nutrition is very real. The inadequacies of calcium and vitamin A can be counteracted by adding milk and vegetables to the diet. It is more difficult to secure adequate thiamine on a high white rice diet because there are so few foods that are rich sources. Thiamine occurs in small

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[1]The term *brown rice* in this bulletin means rice minus its husk, but with the germ, pericarp, and aleurone layers intact.

[2]The term *white rice* means rice with its outer layers removed by power machinery. See FAO Nutritional Studies (*70*) for synonyms for these terms.

amounts in many foods; the basic food in the diet must contain it in appreciable amounts for the diet as a whole to be adequate.

In parts of India, rice is parboiled before milling to make the removal of the husks easier. It has long been known that parboiled rice is effective in preventing beriberi. A modern version of the parboiling method of milling is in use at several of the rice mills of the United States. The general principle is the application of heat and moisture to the rough rice. It is then hulled and milled in the usual way. The resulting product, a polished grain like white rice, is known as processed rice and is marketed under a variety of trade names. When raw, processed rice is straw-colored; when cooked, a creamy white, different from the usual dead white. It has more of a rich whole-grain flavor than does bland white rice. In texture it is as smooth as white rice but not so sticky; the grains are distinct. Processing toughens the grains of rice so that fewer grains are broken during milling.

It is thought that the parboiling process distributes the water-soluble nutrients evenly throughout the grain, so that not so much is lost with the removal of the outer coats and germ. Nicholls (*52*) has recently advanced the explanation that parboiling renders the scutellum (the outer coat of the embryo, rich in thiamine) more adherent so that the milled parboiled grains have more of the scutellum clinging to them than do the grains of ordinary white rice. Hinton (*31*) confirms the retention of the scutellum but has also demonstrated that the endosperm of parboiled rice is definitely higher in thiamine content than that of white rice. Whatever the reason for the higher thiamine content, reports of other workers (*5, 6, 13, 32, 34, 35, 36, 45*) have indicated that the nutritive value and storageability of processed rice are superior. Certainly the conservation of nutritive qualities of rice during milling is a sounder nutrition practice than the addition of synthetic vitamins.

Because of the importance of rice in the food supply of the Islands and the need for a rice of higher vitamin content, a study of processed rice was undertaken with particular reference to its use in Hawaii.

NUTRITIVE VALUE AND FACTORS AFFECTING NUTRITIVE VALUE

by Winifred R. Vinacke and Eva Hartzler

VITAMIN AND MINERAL CONTENT

In order to compare the nutritive value of processed rice with that of brown and white rices, samples obtained from the same source at the same time were analyzed for moisture, thiamine, niacin, calcium, phosphorus, and iron. Six samples of brown rice (numbers 3 to 8), six samples of white (numbers 33 to 38), and six samples of processed (numbers 63 to 68) were obtained direct from one mill at the same time. Samples 12, 42, and 72, brown, white, and processed, were received together from a second mill, and samples 14, 44, and 74 from another mill. In addition, 23 more samples, representative of the rice available to Honolulu consumers, were procured from Honolulu groceries and the University of Hawaii cafeteria. Descriptions of the individual samples are given in Appendix I, page 55.

A table of published values was prepared for the purpose of comparison with our results. References *6, 11, 12, 13, 32, 34, 40, 45, 58, 60, 63, 71,* and *73* in the Literature Cited section were used for this purpose. The nutritive constituents of rice have been studied in Japan, China, and India (*6, 58, 60, 73*). Recent studies in the United States (*13, 32, 34, 35, 71*) have been chiefly concerned with the vitamin content of processed rice, thiamine content being emphasized by most workers. Few determinations of calcium, phosphorus, and iron contents of rice have been reported. Only one source (*6*) could be found reporting the results of determinations of the mineral content of processed rice.

Methods of Analysis

Moisture was determined according to the method recommended by the American Association of Cereal Chemists (*2*). Moisture determinations were done in duplicate except for series of samples received from the same mill at the same time (e.g., samples 3 to 8 constitute a series). For such series, only one determination was done on each sample. Such values never deviated from the mean for the series by more than 3 percent.

For thiamine determinations, the rice was ground in the same manner as for the moisture determinations, and a 4-gram sample of the ground rice was suspended in 10 milliliters of 0.5 N sulfuric acid. The mixture was autoclaved 20 minutes at 15 pounds' pressure, then incubated with Clarase; the resulting extract was analyzed by the thiochrome method. Fluorescence was read in a Coleman photofluorometer. All analyses for thiamine reported in table 1 were done within 2 weeks after receiving the sample from the mill or grocery except for sample 18, as noted under "Description of Samples" in Appendix I. Usually only one extraction for thiamine determination was made for each sample. Duplicate analyses were run on the extract.

Niacin was determined according to the procedure of Hausman, Rosner, and Cannon (*28*). One extraction was made for each sample. Duplicate aliquots of the extract were taken for purification and color development.

Calcium was determined by the method of McCrudden (*41*). All determinations were done in duplicate except for series of samples received from the same mill at the same time. One determination was run on each of such samples.

Phosphorus was determined by the phosphomolybdate volumetric method (*3*). Determinations were done in duplicate except for series of samples. One determination on each sample was done for a series.

To determine iron content, the Saywell-Cunningham (*61*) method of color development with ortho-phenanthroline was followed. An Evelyn photoelectric colorimeter was used for reading the color. Precautions were taken to protect the samples from iron contamination during ashing, filtering, and color development. Determinations were done in duplicate except for series of samples. One determination was done on each sample of a series.

Results and Discussion

Results of moisture, thiamine, niacin, calcium, phosphorous, and iron assays are shown in table 1. These values were determined on the raw rice samples as soon as they were received and represent the initial nutritive content of the rices before storing, washing, or cooking. (Sample 18 had been stored 6 weeks. See Appendix I.) The effects of storage, washing, and cooking are discussed in a later section.

The samples of each kind of rice which were received from the same source at the same time are grouped in the table with average content and range given. The 18 samples, numbers 3 to 8, 33 to 38, and 63 to 68, afford the best comparison of the three kinds of rice because they were all received from the same mill at the same time. Samples 12, 42, 72, 14, 44, and 74 are two other series of brown, white, and processed rice received from the same mill at the same time.

Because of limitations of time or amount of sample not all samples were analyzed for all constituents. Many more thiamine assays were done than niacin or minerals because thiamine is so important a factor in the diet of rice-eating people and because the thiamine content of rice is so greatly affected by milling.

Moisture

Moisture content of processed rice is lower than that of either brown or white. Ranges of moisture content found in this laboratory (see table 1, p. 13) were within published ranges. Only one range of values for the moisture content of processed rice could be found in the literature (*45*).

Thiamine

Thiamine values determined in this laboratory ranged from 396 to 605 micrograms per 100 grams for brown rice, 74 to 118 for white rice, and 97 to 324 for processed rice. Corresponding ranges from the literature are 230 to 506, 37 to 155, and 120 to 375. Our values for brown rice tend to be slightly higher than those in the literature, for processed slightly lower. Our values for white rice are well within the published range.

When a number of samples of a food are analyzed, variations in the nutritive values determined are customarily obtained. No overlapping of thiamine values for white and brown rice is recorded either in the literature or in this study. Processed rice, however, shows a wide range of thiamine content, which, in the literature, overlaps both white and brown values. In this study, all our processed

TABLE 1. Moisture, thiamine, niacin, calcium, and iron contents of brown, white, and processed rice.

RICE SAMPLE NUMBERS*	MOISTURE	THIAMINE	NIACIN	CALCIUM	PHOSPHORUS	IRON
	Percent	*Mcg/100 gm*	*Mg/100 gm*	*Mg/100 gm*	*Mg/100 gm*	*Mg/100 gm*
Brown rice						
3, 4, 5, 6, 7, 8	14.1–14.3	396–469	5.0–5.3	7–8	158–175	0.6–1.1
Average	14.2	431	5.2	8	166	0.8
10	....	415	....	7	307	0.6
12	13.7	605	....	10.5	....	....
14	12.6	457	....	9	....	....
17 and 18	13.5	450–540	....	....	....	....
White rice						
33, 34, 35, 36, 37, 38	14.0–14.6	81–101	1.7–2.3	9–10	93–100	0.2–0.25
Average	14.2	91	1.9	9	97	0.2
40 and 41	12.8–12.9	99	....	4–7	110–114	0.3
42	13.9	99	....	16	....	....
44	13.4	74	....	64	....	....
46 and 47	12.4–12.8	104–118	....	....	....	....
Processed rice						
63, 64, 65, 66, 67, 68	12.5–13.1	148–171	5.6–6.1	14–20	127–159	0.2–0.4
Average	12.9	157	5.9	17	144	0.3
62	10.6	174	5.9	....	....	....
72	13.4	324	....	23	....	....
73	12.5	97	....	44	....	....
74	12.9	308	....	68	....	....
75	12.7	284	....	273	....	....
76, 77, 78	12.9–13.5	158–201	....	7–23	182–193	0.4–0.9
Average	13.2	178	....	16	187	0.6
79, 80, 81, 82, 83	11.6–12.8	124–195	....	....	....	....
Average	12.2	170	....	....	....	....
84	11.4	155	....	....	....	....
86 and 87	11.8	290	....	....	....	....
Unhusked rice						
94	12.7	375	....	....	....	....

*For descriptions of the samples see Appendix I, page 55.

rice samples were lower in thiamine content than the brown samples, but only one was as low as the highest white rice sample.

It should be kept in mind that the differences in thiamine content of the three kinds of rice, as shown in table 1, were determined on the fresh raw-weight basis, and that storage, washing, and cooking may alter them considerably.

Niacin

Niacin values, reported in table 1, are 5.0 to 5.3 milligrams per 100 grams for brown rice, 1.7 to 2.3 for white rice, and 5.6 to 6.1 for processed rice. Processed values are higher than brown values, possibly because the samples analyzed came from different lots, and the brown rice from which the processed rice was made may have had a higher content than the brown rice analyzed. Our values are all within the range reported in the literature.

Calcium

More assays of calcium than of phosphorus and iron were done because our first results were so different from those reported in the literature and because processed rice was unexpectedly higher in calcium than either brown or white.

The range of calcium contents of white and processed rice as shown in table 1 is very large. Analysis of 13 samples of processed rice gave a mean value of 43 milligrams of calcium per 100 grams, with a range of 7 to 273. Only one value for processed rice could be found in the literature (*6*)—3 milligrams calcium per 100 grams. Our white rice values for 10 samples ranged from 4 to 64 with a mean value of 15 milligrams per 100 grams. An even greater range can be found in the literature. A previous study in this laboratory found white rice to have a small calcium content (*55*). Brown rice was consistently low in calcium content according to our analyses, lower than the published minimum.

Other workers (*58, 60*), as well as this laboratory, report some calcium values for white rice that are higher than brown rice values. The use of calcium carbonate as a milling aid in scouring the bran from the endosperm may be responsible for the higher calcium content of white rice. The processed rice which we analyzed is definitely higher in calcium content than brown or white rice from the same sources. A contributing factor may be the use in processing of water containing calcium. One mill reported that the water they were using contained 53 ppm. CaO (*46*).

Phosphorus

Phosphorus determinations were made on only a limited number of samples because our results agreed well with values in the literature.

Iron

Mean contents of iron determined in this laboratory were 0.8 milligram per 100 grams for brown rice, 0.2 for white rice, and 0.4 for processed. These values are lower than any reported in the literature. It is possible that some of the published data were obtained without taking all possible precautions to guard against iron contamination during the preparation and analysis of the samples. Other investigators have called attention to the need for great care in making iron analyses of food and to the fact that the values obtained when special precautions are observed are likely to be lower than average figures (*65*).

Summary and Conclusions

Samples of brown, white, and processed rice from the same sources have been analyzed for moisture, thiamine, niacin, calcium, phosphorus, and iron.

Samples of raw fresh processed rice have higher thiamine, niacin, calcium, phosphorus, and iron contents than do samples of white rice. Mean values of the samples analyzed show processed rice to be 101 percent higher in thiamine content, 210 percent higher in niacin, 197 percent higher in calcium, 56 percent higher in phosphorus, and 78 percent higher in iron than white rice. Processed rice contains less than brown rice of all these nutrients except calcium and niacin.

Milling of brown rice results in loss of nutrients. Less than one-fifth of the thiamine present in brown rice is retained in milled white rice, but if the rice is processed before milling more than a third of the thiamine is retained. White rice contains only one-fourth of the iron of brown rice, while processed rice retains one-half. Somewhat over half of the phosphorus of brown rice is present in white rice, but processed rice contains seven-eighths of the phosphorus of brown rice.

The effects of storage, washing, and cooking on the nutritive contents of rice are discussed in the following section.

FACTORS AFFECTING THE VITAMIN AND MINERAL CONTENT

Storage

Rice may be stored in warehouses or retail stores for several months before it is bought by the ultimate consumer, and it may be stored several months longer in the home before it is actually used. Storage would not be expected to have any effect on the mineral content of rice, but since the thiamine and niacin contents of other foods decrease with storage, it might be expected that the vitamin content of rice would be affected.

Other workers (*13, 34, 36, 45*) have studied the effects on thiamine and niacin content of storage of rice in the laboratory and found 0 to 30 percent loss of thiamine and 4 to 13 percent loss of niacin in 6 months to 2½ years. No studies have been reported of thiamine and niacin contents of rice actually stored under commercial warehouse conditions. Since rate of loss may be influenced by climate and the protection of the warehouse, storage losses determined under one set of conditions are apt to be different from storage losses determined elsewhere.

To determine what losses of thiamine and niacin could be expected in rice stored in Honolulu warehouses and homes, samples of rice were stored under typical conditions and their thiamine and niacin contents determined at intervals.

Procedure

Eighteen 100-pound sacks of rice, six each of brown, white, and processed, received direct from the mill, were stored, in the burlap sacks in which they were shipped, in two Honolulu warehouses which offered different storage conditions. These rices—samples 3–8, 33–38, 63–68—were stored for 16 weeks, January to May, 1947, and sampled at 4-week intervals. Insect infestation of these rices was studied by the Entomology Department of the Hawaii Agricultural Experiment Station (see p. 36). A recording thermometer and hygrograph were placed in each warehouse. The instruments were adjusted, using a wet and dry bulb thermometer as a standard at the beginning of the storage period, and their accuracy was checked at the end of the period. There was no deviation in the measurement of humidity and less than 1 degree deviation in temperature.

Approximately 4 pounds of rice were removed from each of the sacks before they were taken to the warehouse. For extended storage under laboratory conditions, each lot was placed in a metal can with a tight-fitting cover, fumigated with carbon disulfide (*49*), and stored on a shelf in the Nutrition Laboratory. No temperature or humidity records were kept for this laboratory experiment. These rices were stored for 18 months and sampled at approximately 6-month intervals.

Description of the warehouses: Warehouse A stored the rice on the second story. A wooden platform raised the bags 6 inches off a wooden floor. From time to time other rice was stored in the vicinity, but usually canned goods were stored there. There were no windows in the concrete walls and the door was shut at night. Even in the daytime the light was quite dim. This warehouse was sprayed twice a week with a pyrethrum spray.

Warehouse B stored the rice on the ground level, directly on a concrete floor. This warehouse had no walls, but strong steel fencing between the supports of the roof surrounded the goods. Thus the rice was not protected from wind, dust, or moist air, but the shelter of the roof kept away rain and direct sunlight. Potatoes, rice, and miscellaneous staples were also stored in this room.

Method of sampling: The sacks of rice stored in the warehouses were sampled before they were stored and at 4-week intervals until they had been stored for a total of 16 weeks. The samples were taken with a grain sampler, which was inserted twice in each sack: once through the center of the sack of grain, and once down one side. The two cores were mixed on a large piece of paper and transferred to a glass jar with a screw lid.

Samples were removed with a spoon from the lots of rice stored under laboratory conditions. These samples, of approximately 100 grams, were placed in Erlenmeyer flasks and kept tightly corked until they were ground for analysis.

The individual samples were ground in an electric mill and kept in airtight containers during the period they were being analyzed.

Methods of analysis: The samples were analyzed for moisture, thiamine, and niacin by the methods previously described on page 11. One determination was run on each sample. The range of determined values for the three samples of one kind of rice in one warehouse never exceeded 10 percent.

Results

Moisture, thiamine, and niacin values of rice stored in the two warehouses are given in table 2 with mean temperature and humidity values and their ranges. The range of temperature was 17° to 32° C. (63° to 88° F.). The humidity varied from 32 percent to 100 percent[3] with the means being 58 percent and 66 percent for the two warehouses. Temperatures in warehouse B tended to be lower, but humidity was definitely higher. Ranges of both temperature and humidity were greater in warehouse B.

The decrease in thiamine content of the rices and the degree of insect infestation are depicted in figure 1. The weekly mean and low temperature and humidity are also shown.

Effects of warehouse storage on moisture content: Processed rice consistently showed lower moisture values than white or brown throughout the storage period in both warehouses. This fact may have some influence on amount of insect infestation (see p. 39).

All rices tended to become drier during the first 12 weeks of storage, but showed slightly higher moisture content at the end of 16 weeks than at the end of 12 weeks. The last 4 weeks of storage were marked by frequent rain, and the humidity, both mean and minimum values, was decidedly higher in both warehouses although the temperature was about the same. These results might indicate that the rise in moisture content was caused by the rise in humidity were it not for the fact that the humidity in warehouse B was always noticeably higher than that in warehouse A, yet the moisture values for the rices were not significantly different. Moisture determinations were made at 4-week intervals, which is not often enough to observe a trend in response to humidity conditions.

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[3]The accuracy of the hygrograph is 5 percent.

TABLE 2. Thiamine and niacin contents of rices before and at intervals during 16 weeks' storage in two Honolulu warehouses.

	WEEKS' STORAGE				
	0	4	8	12	16
Warehouse A					
Thiamine content of rice (in micrograms per 100 grams*)					
Brown rice	432	284	275	281	259
White rice	87	61	51	48	51
Processed rice	151	145	145	134	123
Niacin content of rice (in milligrams per 100 grams*)					
Brown rice	5.2	4.7	4.3	4.4	4.3
White rice	2.0	1.6	1.4	1.5	1.4
Processed rice	5.9	5.6	5.4	5.1	4.9
Moisture content of rice (percent*)					
Brown rice	14.2	13.6	12.9	13.0	13.4
White rice	14.2	13.8	13.5	13.5	13.7
Processed rice	13.0	12.5	12.5	12.1	12.3
Mean temperature (°C.)		25	26	26	26
Range of temperature (°C.)		19–30	20–31	21–31	23–30
Mean humidity (percent)		55	59	56	63
Range of humidity (percent)		32–79	34–81	37–80	44–86
Warehouse B					
Thiamine content of rice (in micrograms per 100 grams*)					
Brown rice	429	323	322	338	319
White rice	96	98	89	68	70
Processed rice	163	147	144	133	137
Niacin content of rice (in milligrams per 100 grams*)					
Brown rice	5.2	4.6	5.0	4.4	4.5
White rice	1.9	1.6	1.5	1.6	1.5
Processed rice	6.0	5.6	5.4	5.2	5.2
Moisture content of rice (percent*)					
Brown rice	14.2	13.5	12.9	13.3	13.7
White rice	14.3	13.9	13.6	13.4	13.7
Processed rice	12.8	13.8	12.4	11.8	12.2
Mean temperature (°C.)		24	24	23	24
Range of temperature (°C.)		17–32	19–29	19–28	21–28
Mean humidity (percent)		65	66	65	70
Range of humidity (percent)		32–96	36–100	36–96	44–96

*Each value represents an average of determinations on three samples, each from a different sack of rice.

Effect of warehouse storage on thiamine content: As shown in table 2, the thiamine contents of all rices decreased during storage. Analysis of duplicate samples of rice by the thiochrome method in this laboratory as well as analysis of other foods elsewhere (*4*) have indicated that results that agree within 5 percent are as accurate as can be obtained. Therefore, differences in determined values of less than 5 percent are not considered true differences.

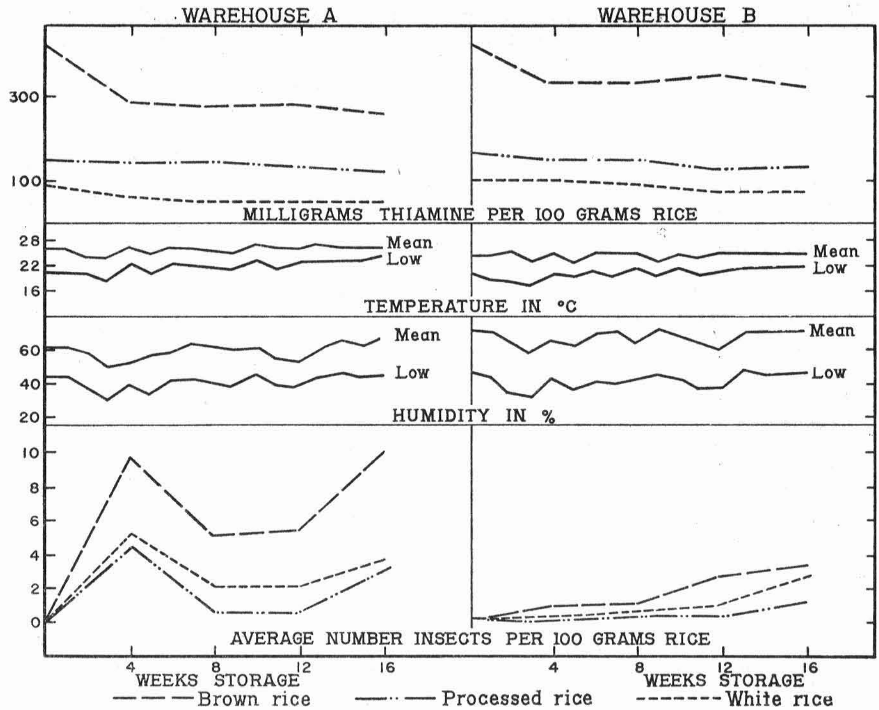

Figure 1.—Thiamine content and insect infestation of brown, processed, and white rice held in two Honolulu warehouses. Temperature and humidity readings taken in the two warehouses during the storage period are indicated for reference.

In both warehouses the thiamine content of brown rice showed a sharp drop during the first 4 weeks. Changes after that were insignificant in warehouse B. In warehouse A another drop occurred at the 16th week. Loss of thiamine of brown rice during 16 weeks of storage was 40 percent in warehouse A, 26 percent in warehouse B.

Thiamine content of white rice in warehouse A dropped slowly for 8 weeks and then leveled off. In warehouse B the thiamine content remained fairly constant for 8 weeks, then dropped rather sharply and remained constant again. Loss during 16 weeks was 41 percent in warehouse A, 27 percent in warehouse B.

The thiamine content of processed rice decreased more gradually than that of the other two rices. The change was not significant until the 12th week in warehouse A. In warehouse B there was a slight loss during the first 4 weeks and at the end of 8 weeks. Total loss of thiamine at the end of 16 weeks was 18 percent in warehouse A, 16 percent in warehouse B.

There was considerably less loss of thiamine in rices stored in warehouse B than in those in warehouse A. The exact reason is not known. The mean weekly temperature was 1 to 3 degrees lower in warehouse B. The weekly low temperatures were 1 to 2 degrees lower. The mean humidity was 7 to 10 percent higher in warehouse B, the high humidity was 10 to 19 percent higher. The insect infestation is considerably lower in warehouse B (see table 12, p. 38). Any or all of those factors or others might be responsible for the rate of loss of thiamine. Further study is needed to demonstrate which of these factors are the most influential ones and how they operate.

Effect of warehouse storage on niacin content: Niacin values also decreased with storage, but more gradually than thiamine values. The limits of accuracy of the method of analysis used are such that differences of less than 0.5 milligram per 100 grams are not actual differences.

By this criterion, there was a slight loss of niacin in brown rice during the first 4 weeks in warehouse A. No further loss occurred. In warehouse B there was a slight drop after 8 weeks' storage.

White rice showed a slight decrease at the end of 8 weeks in warehouse A, no decrease in warehouse B.

Processed rice also showed a gradual loss of niacin, the difference becoming significant at 8 weeks.

There was a difference in every instance between the values determined at the beginning of storage and at the end of 16 weeks. However, there was no demonstrable difference between the niacin values of the rices stored in different warehouses.

Effect of laboratory storage on thiamine and niacin contents: In table 3 are shown moisture, thiamine, and niacin contents of brown, white, and processed rice after 7, 12, and 18 months' storage under laboratory conditions. (See page 15 for method of storage.)

Although the rices had been fumigated with carbon disulfide and were kept in metal cans, insects were apparently able to get into the cans. At the end of 18 months a few rice weevils, *Sitophilus oryza,* were observed in four cans and at the end of 20 months 14 of the 18 samples were so badly infested that they had to be discarded.

TABLE 3. Thiamine and niacin contents of rices before and at intervals during 18 months' storage under laboratory conditions.

	MONTHS' STORAGE			
	0	7	12	18
Thiamine content (in micrograms per 100 grams*)				
Brown rice	431	300	306	268
White rice	91	82	75	78
Processed rice	157	124	120	104
Niacin content (in milligrams per 100 grams*)				
Brown rice	5.2	4.6	4.2	4.7
White rice	1.9	1.4	1.3	1.3
Processed rice	5.9	5.0	4.8	5.0
Moisture content (percent*)				
Brown rice	14.2	14.0	14.8	14.7
White rice	14.2	13.9	14.4	14.3
Processed rice	12.9	12.8	13.9	13.8

*Each value represents an average of determinations on six samples, each from a different lot.

At the end of 7 months' storage under laboratory conditions brown rice had lost 30 percent of its thiamine, white rice 10 percent, and processed rice 21 percent. Losses of thiamine in brown and processed rice were the same as those observed during 4 months of warehouse storage. White rice, however, lost less thiamine when stored under laboratory conditions than when stored under warehouse conditions.

At the end of 18 months white rice still showed the smallest loss of thiamine, 14 percent, while brown and processed lost 38 and 34 percent, respectively, of their original content.

Although there is a difference in retention of thiamine of rice stored under laboratory and warehouse conditions, the conditions were different in several respects and it is difficult to say which was responsible. Rice stored under laboratory conditions was free from insect infestation for a long period because of treatment with carbon disulfide; it was stored in small lots in metal containers rather than burlap sacks; it was stored in a dark cupboard, which was probably slightly cooler than the warehouses. It is impossible to say which of these factors is responsible for the smaller loss of thiamine in white rice. The continued loss of thiamine in brown rice and processed rice may be attributed to the length of storage.

Brown, white, and processed rice showed essentially the same retention of niacin at the end of 7 months' household storage as at the end of 16 weeks' warehouse storage. After that the niacin content continued to decline slowly.

In addition to the data shown in tables 2 and 3, a sample of brown rice (number 1) was analyzed for thiamine at the end of 1 year's storage; another (sample 16) was analyzed at the end of 18 months. The two determined values, 358 and 212 micrograms of thiamine per 100 grams rice, are well below the minimum values reported in table 1. A sample of processed rice (number 61) analyzed after 1 year's storage was found to contain 149 micrograms of thiamine per 100 grams, a value close to the minimum shown in table 1. The length of time the sample of rice has been stored before analysis would be valuable information to accompany published thiamine values.

Summary

Brown, white, and processed rices have been stored under typical warehouse conditions and under laboratory conditions. Determination of the thiamine and niacin contents at intervals has indicated that there is a loss of thiamine and niacin during storage for all three kinds of rice. Processed rice showed the smallest percentage loss of thiamine during 4 months' warehouse storage, white rice the smallest loss during 18 months' laboratory storage. Percentage losses of niacin were smaller than those of thiamine. An interesting aspect of this problem for further study is the influence of insect infestation on thiamine loss. Since the rice in warehouse B showed higher thiamine retention and lower total insect infestation for all rices, and since the white rice stored under laboratory conditions showed even higher thiamine retention and no insect infestation, the correlation of the two factors thus suggested would bear investigation.

Washing

It is a common practice to wash rice before cooking. Oriental people wash rice thoroughly in as many as seven changes of water. This practice may have developed at a time when talc was used as a coating for white rice grains or when rice was open to dust in an outdoor market. Other workers have reported losses of thiamine and niacin in washing rice (*34, 45*). A previous study at this Station, using the rat-growth method of assay, could demonstrate no loss of thiamine in washing brown rice five times (*48*).

By using the chemical method of analysis, many samples of brown, white, and processed rice could be assayed before and after washing. Rices available in Hawaii and methods of washing commonly used in Hawaii were studied in this laboratory. Losses of thiamine were determnied in washing 13 samples of rice; losses of calcium, phosphorus, and iron in washing five samples of rice.

Procedure

Five samples of brown rice, four of white, and eight of processed rice were selected for this study. Six of these 17 samples (as indicated in table 4) were washed one, five, and seven times. One hundred to 400 grams of rice were placed in a large beaker; twice the amount of distilled water was added; the rice was stirred briskly eight times and the water decanted. Small portions of rice were removed for analysis at the end of one, five, and seven washings. To determine the reproducibility of our results one sample (number 80) was divided into two lots, which were washed and sampled separately but in exactly the same manner. Seven of the lots were sampled only after one washing or after seven washings.

The washed samples were drained on paper towels and allowed to dry overnight at room temperature. They were ground and moisture was determined so that they could be compared with the values for unwashed rice. Moisture values of washed rice were never over 17 percent.

Three of the samples, numbers 3, 37, and 66, were washed in a different manner by placing 17 grams of the rice in a colander and pouring over it five successive washings of 30 milliliters of distilled water. The entire washed sample was transferred to a flask and analyzed immediately for thiamine.

Moisture determinations were done in duplicate. For thiamine analyses, one extraction was made from each sample and duplicate determinations were made on each extract. Mineral analyses were done in duplicate.

Results

The thiamine, calcium, phosphorus, and iron contents of unwashed and washed samples of rice are shown in table 4.

Effect of washing on thiamine content: Brown rice shows high retention of thiamine during washing, 64 to 98 percent. White rice shows the lowest retention, 32 to 78 percent. The retention of thiamine in processed rice is similar to that of brown, 67 to 92 percent. All rices show successively higher losses of thiamine with continued washing. Repeated washing of white rice results in a loss of more than half of the already low thiamine content.

There are two values given for sample 80 because it was divided into two lots which were washed separately. The determined values on the washed samples vary as much as 17 percent. These differences were probably caused by small differences in the length of time the rice was in contact with the wash water. They indicate the range of loss of thiamine that may be expected in washing processed rice.

Effect of washing on calcium content: There is practically no loss of calcium in washing brown or white rice. Processed rice, however, loses almost all of its

TABLE 4. Effect of washing on thiamine, calcium, phosphorus, and iron contents of brown, white, and processed rice.

	THIAMINE		CALCIUM		PHOSPHORUS		IRON	
	mcg/100 gm	Percentage Retention	mg/100 gm	Percentage Retention	mg/100 gm	Percentage Retention	mg/100 gm	Percentage Retention
Brown rice*								
Sample 3								
Raw	296							
Washed 5 times†	289	98						
Sample 10								
Raw	415		7.2		307		0.61	
Washed 7 times†	359	86	6.9	96	281	92	0.51	84
Sample 16								
Raw	212							
Washed 1 time†	191	90						
Washed 5 times	174	82						
Washed 7 times	164	77						
Sample 17								
Raw	540							
Washed 1 time†	464	86						
Washed 5 times	380	70						
Washed 7 times	347	64						
Sample 18								
Raw	450							
Washed 1 time†	428	95						
Washed 5 times	421	94						
Washed 7 times	387	86						
White rice*								
Sample 37								
Raw	86							
Washed 5 times†	46	54						
Sample 40								
Raw	99		4.0		114		0.34	
Washed 7 times†	32	32	4.3	107	97	85	0.15	44
Sample 46								
Raw	118							
Washed 1 time†	93	78						
Washed 5 times	44	37						
Washed 7 times	41	35						

Table 4—continued

	THIAMINE		CALCIUM		PHOSPHORUS		IRON	
	mcg/100 gm	Percentage Retention	mg/100 gm	Percentage Retention	mg/100 gm	Percentage Retention	mg/100 gm	Percentage Retention
Sample 47								
Raw	104							
Washed 1 time†	79	76						
Washed 5 times	46	44						
Washed 7 times	39	37						
Processed rice*								
Sample 66								
Raw	132							
Washed 5 times†	120	91						
Sample 76								
Raw	176		6.8		182		0.88	
Washed 7 times†	148	84	4.9	72	136	75	0.53	60
Sample 77								
Raw	158		23.4		193		0.53	
Washed 7 times†	123	78	8.6	37	134	69	0.30	57
Sample 78								
Raw			18.8		187		0.38	
Washed 7 times†			3.8	20	116	62	0.13	34
Sample 79								
Raw	124							
Washed 1 time†	114	92						
Sample 80								
Raw	195							
Washed 1 time†	157–180	81–92						
Washed 5 times	135–163	69–84						
Washed 7 times	131–149	67–76						
Sample 81								
Raw	178							
Washed 1 time†	164	92						
Washed 5 times	146	81						
Washed 7 times	138	78						
Sample 82								
Raw	175							
Washed 1 time†	160	92						
Washed 7 times	140	80						

*For description of these samples see Appendix I, page 55.
†All values for washed samples are corrected to the same moisture content as the raw sample.

calcium content in washing. Although unwashed processed rice is markedly higher in calcium content than brown or white (see p. 14), the calcium content of washed processed rice is as low as or lower than that of washed brown or white rice.

Effect of washing on phosphorus content: Brown rice lost only 8 percent of its phosphorus in washing, white rice lost 15 percent, and processed rice lost 25 to 38 percent. Processed rice retained more phosphorus than calcium.

Effect of washing on iron content: All rices lost some iron in washing. White rice, which has the lowest original content, lost the most iron, 56 percent. The average iron content of washed processed rice samples was between the values for washed brown and washed white rice.

Summary

Determinations of the thiamine, calcium, phosphorus, and iron contents of brown, white, and processed rice before and after washing indicate that more than half of the thiamine and iron content of white rice may be lost by washing, one-fourth of the thiamine of brown rice, and as much as one-third of that of processed rice.

Some phosphorus is lost in washing all rices. A large part of the calcium of processed rice is lost during washing but none of the calcium of brown and white rice. With seven washings, brown rice lost 16 percent of its iron, white rice 56 percent, and processed rice 50 percent.

Brown rice loses a smaller percentage of its nutrients during washing than do white and processed rice.

Cooking

Residents of the mainland United States cook rice by several different methods—by boiling in large amounts of water, or by cooking in the oven, the double boiler, or the pressure saucepan. Orientals practically always boil rice, using a small amount of water which is absorbed by the rice. While mainland Caucasians customarily salt rice during cooking, Oriental people do not.

Since processed rice is a comparatively new product in America, it was not known whether methods of cooking white and brown rice would produce a good cooked product when used with processed rice. The University of Hawaii Home Economics Department cooperated with the Experiment Station in determining the best method of cooking processed rice. Different proportions of water and rice and different lengths of cooking time for boiled rice were tested on gas, electric, and kerosene stoves. Directions for preparing boiled processed rice, developed in this manner, are given in Appendix II, page 56. Similar trials were made of cooking rice in the oven and in the pressure saucepan and are reported in Appendix II. The pressure saucepan method does not give as light and fluffy a product as does the boiling method and is not recommended. Not only is the cooked product inferior, but the retention of thiamine is low (see p. 26).

Some loss of thiamine in cooking might be expected since thiamine is heat labile. Other workers (*6, 34, 45*) have studied the effect of cooking on the thiamine content of rice. Losses reported have ranged from 0 to 67 percent. Losses caused by cooking plus losses caused by discarding the cooking water are always high (*45*).

In this study, losses of thiamine in cooking processed rice by five different methods, and losses of thiamine in cooking brown and white rice by two methods, were determined.

Procedure

To determine the loss of thiamine in cooking processed rice by different methods eight samples of processed rice were cooked in various ways. Thiamine and moisture values were determined for the raw and cooked samples, and the thiamine contents were compared on the original moisture basis. Thiamine content of cooking water was also determined. To compare the losses of thiamine in cooking brown, white, and processed rice, samples of these rices from the same sources were cooked by the same method.

Rice samples: Three samples of brown rice were used, two of white, and eight of processed. These are referred to by number in tables 5 and 6. Descriptions of the samples are given in Appendix I.

Methods of cooking: All rices in this study were cooked on a gas stove. In tables 5, 6, and 7 the cooking methods are identified by number. Detailed directions for each method are given in Appendix II.

To determine the cumulative effects of washing and cooking on the same samples of rice, five samples were washed before cooking. These results are reported in table 7. No other rices were washed before cooking.

Methods of analysis: Thiamine and moisture contents of raw rice samples were determined by the methods stated on page 11.

Moisture content of cooked samples was determined by drying duplicate 2- to 10-gram samples at 80° C. for 48 hours. The dishes were then placed in a desiccator over Dehydrite, air was removed with a vacuum pump, and the dried samples kept under this low pressure for 24 hours.

For thiamine determinations 50 grams of the cooked rice were blended with 150 milliliters of water in a Waring Blendor. Duplicate aliquots of this suspension were taken and analyzed as described on page 11. Aliquots of the cooking water were analyzed by the same method.

Results

Losses of thiamine in cooking processed rice by different methods: The losses of thiamine in cooking processed rice by five different methods are shown in table 5. Cooking seven samples of processed rice by the standard method developed by this laboratory (Method 1, p. 56) resulted in an average loss of 29 percent of the thiamine. By following directions on one of the packages of rice (Method 1b, p. 56) more water was used and a more moist cooked rice was obtained. The loss of thiamine for this method was 20 percent. Processed rice showed least loss, 18 percent, when cooked by the oven method, despite the high temperature used—400° F. Of the methods in which the water is absorbed by the rice, cooking in the pressure saucepan produced the highest loss, 48 percent. Since this method also produced the driest rice (47 percent moisture), and since cooking in the double boiler or in the oven produced cooked rice with high moisture content (70 percent) and high thiamine retention, and since increasing the amount of water in the standard method decreases the loss of thiamine, the evidence suggests that a moist cooked rice will have a higher thiamine content than a dry cooked rice.

TABLE 5. Losses of thiamine in cooking processed rice by different methods.

COOKING METHOD*	RICE SAMPLE NUMBERS†	PERCENTAGE LOSS OF THIAMINE	
		Range	Average
Standard method (Method 1)....	72, 79, 80, 81, 82, 86, and 87	21 to 36	29
Standard method with increased water (Method 1–b).........	86 and 87	16 to 25	20
Double boiler (Method 2)......	86 and 87	20 to 22	21
Oven (Method 3).............	82 and 83	14 to 21	18
Pressure saucepan (Method 4)...	81 and 83	43 to 53	48
Cooking in large amounts of water (Method 5)	72, 80, 81, and 83	47 to 58	54
Loss caused by destruction in cooking		(6 to 18)	(12)
Loss caused by discarding cooking water		(34 to 49)	(42)

*For descriptions of cooking methods see Appendix II, page 56.
†For descriptions of samples see Appendix I, page 55.

TABLE 6. Losses of thiamine in cooking brown, white, and processed rice.

COOKING METHOD*	RICE SAMPLE NUMBERS†	PERCENTAGE LOSS OF THIAMINE		
		In cooking	In cooking water	Total
Standard method (Method 1)				
Brown rice	16, 17, and 18	18	....	18
White rice	46 and 47	9	....	9
Processed rice	79, 80, 81, 82	30	....	30
Cooking in large amounts of water (Method 5)				
Brown rice	16, 17, and 18	13	38	51
White rice	47	5	7	12
Processed rice	72, 80, 81, 83	12	42	54

*For descriptions of cooking methods see Appendix II, page 56.
†For descriptions of samples see Appendix I, page 55.

Cooking processed rice in excess water and then discarding the cooking water resulted in the highest loss of thiamine, 54 percent. The larger part of this loss (42 of the 54 percent) was caused by discarding the cooking water.

Losses of thiamine in cooking brown, white, and processed rice: In table 6 are shown the losses of thiamine in cooking brown, white, and processed rice by the same method. There was a loss of 18 percent of the thiamine in cooking brown rice by the standard method and a smaller loss in cooking white rice, 9 percent. Processed rice showed the highest loss, 30 percent. When cooked in large amounts of water which was discarded (see Method 5, p. 56), brown rice and processed rice lost 51 and 54 percent of their thiamine content, and white rice again showed the least loss, 12 percent.

Losses of thiamine in washing and cooking rice: Losses of thiamine in washing and cooking rice have been determined separately and reported in tables 4, 5, and 6. In actual practice, however, rice is both washed and cooked and the two losses must be considered together. It would be expected that the two losses would be additive. To determine whether this is true, losses in cooking washed and unwashed rice were determined for seven samples. Results are shown in table 7.

As would be expected, the total losses for cooking washed white and processed rice in large quantities of water (Method 5) are greater than those for cooking without washing. The unexpected result is that processed rice cooked by the standard method (see Method 1, p. 56) shows the same or smaller total loss if it is washed once before cooking. Brown rice which is thoroughly washed before cooking tends to lose less thiamine in the cooking water than does unwashed rice.

TABLE 7. Losses of thiamine in cooking washed and unwashed rice.

KIND OF RICE	COOKING METHOD*	NO. OF WASHINGS	PERCENTAGE LOSS OF THIAMINE			
			In washing	In cooking	In cooking water	Total
Brown rice	5	0	0	8	57	65
		7	23	14	32	69
	5	0	0	32	18	50
		7	35	20	17	72
	5	0	0	1	39	40
		7	13	27	21	61
White rice	5	0	0	5	7	12
		7	61	10	0	71
Processed rice	5	0	0	12	42	54
		7	21	38	24	83
	1	0	0	24	..	24
		1	8	16	..	24
	1	0	0	36	..	36
		1	8	22	..	30

*For descriptions of cooking methods see Appendix II, page 56.

These results indicate that the entire cooking procedure must be considered as a unit in determining cooking losses. Losses from washing and cooking may be additive, or the loss in cooking may depend on the amount previously lost by washing.

Summary and conclusions

Brown, white, and processed rice have been cooked by different methods and the losses of thiamine determined. Rice which is not washed, or washed only once, and cooked in amounts of water which can be absorbed will show maximum retention of thiamine. Cooking in large amounts of water, which is discarded, and cooking in the pressure saucepan cause more loss of thiamine than other methods. A moist cooked rice will tend to retain more thiamine than a dry cooked rice.

TABLE 8. Amounts of thiamine, niacin, calcium, phosphorus, and iron in 1 pound (raw weight) of brown, white, and processed rice.

	THIAMINE	NIACIN	CALCIUM	PHOS-PHORUS	IRON
	micrograms	*milligrams*	*milligrams*	*milligrams*	*milligrams*
National Research Council allowance (*26*) for moderately active man.....	1,500	15	800	1,200	12
Initial					
Brown rice	1,950	24	36	985	3.5
White rice	435	9	36	458	1
Processed rice	755	27	77	717	2
After 4 months' storage in warehouse					
Brown rice	1,310	20	...	...	..
White rice	285	7	...	...	..
Processed rice	625	23	...	...	..
After 18 months' storage under laboratory conditions					
Brown rice	1,210	21	...	...	..
White rice	372	6	...	...	..
Processed rice	500	23	...	...	..
After 1 washing					
Brown rice	1,757	..	...	...	..
White rice	335	..	...	...	..
Processed rice	670	..	...	...	..
After 7 washings					
Brown rice	1,520	..	35	906	2.9
White rice	150	..	36	379	0.4
Processed rice	580	..	33	495	1.0
After cooking, Method 1*					
Brown rice	1,600	..	...	...	..
White rice	395	..	...	...	..
Processed rice	535	..	...	...	..
After cooking, Method 5*					
Brown rice	955	..	...	...	..
White rice	385	..	...	...	..
Processed rice	345	..	...	...	..
After storage 4 months, 7 washings, and cooking, Method 1*					
Brown rice	840	..	...	...	..
White rice	90	..	...	...	..
Processed rice	340	..	...	...	..

*For descriptions of cooking methods see Appendix II, page 56.

Significance of the Results

Those who eat rice as their basic cereal food may consume as much as 1 pound, raw weight, daily. For people on such a diet it is important to know how much of the different dietary constituents this amount of rice can be expected to supply. These quantities must be compared with the need of the individual before we can say that rice is an excellent, good, or poor source of any one of the necessary dietary constituents.

In table 8 are shown the amounts of thiamine, niacin, calcium, phosphorus, and iron in 1 pound of fresh, raw, uncooked, brown, white, and processed rice and the daily allowance for these nutrients recommended by the National Research Council. As reported in this bulletin, these values change with storage, washing, and cooking. Therefore, the amounts of these nutrients present in 1 pound of rice which has been stored, washed, or cooked are also indicated.

Determined values for California rices only were used in preparing table 8. Most of the brown and white rice and all of the processed rice on the market in Hawaii are grown and milled in California.

When a pound of fresh, raw, unwashed rice is compared with the recommended daily allowances, as shown in table 8, it is apparent that brown rice contains enough thiamine and niacin to fulfill these requirements; white rice will supply less than a third of the required thiamine and almost two-thirds of the niacin; while a pound of processed rice contains half the thiamine allowance and more than enough niacin. Brown rice contains three-fourths of the necessary phosphorus, white rice only a third, and processed rice more than two-thirds. All the rices make negligible contributions of calcium and iron, although processed and brown contribute more than white.

Rice which has been stored for 4 months in a warehouse does not contain so much thiamine and niacin as fresh rice. A pound of brown rice can still satisfy the niacin requirement and supply 87 percent of the thiamine requirement; a pound of processed rice contains two-fifths of the required thiamine and all the needed niacin; however, a pound of white rice contains less than one-fifth of the needed thiamine and only one-third of the niacin.

If the fresh rice is washed once, the brown rice still furnishes more than enough thiamine and the processed rice close to half enough. White rice contains about one-fifth the required amount.

Washing seven times reduces the contribution of thiamine of white rice to one-tenth of the necessary amount. Brown rice washed seven times still contains enough thiamine and processed rice contributes one-third of the recommended daily allowance. The contribution of calcium of brown and white rice is not changed by washing but washed processed rice contributes only a twentieth instead of a tenth of the needed amount. Phosphorus content is decreased so that 1 pound of brown rice contributes two-thirds of the daily allowance, processed two-fifths, and white one-third. Iron content is reduced by excessive washing so that brown rice contains one-fourth of the needed amount, processed rice one-twelfth, and white rice one-thirtieth.

Cooking method is also a factor in determining the amount of nutrients the consumer will get from his pound of rice. Cooking without discarding cooking water (see Method 1, p. 56) leaves considerable amounts of thiamine in the rice—

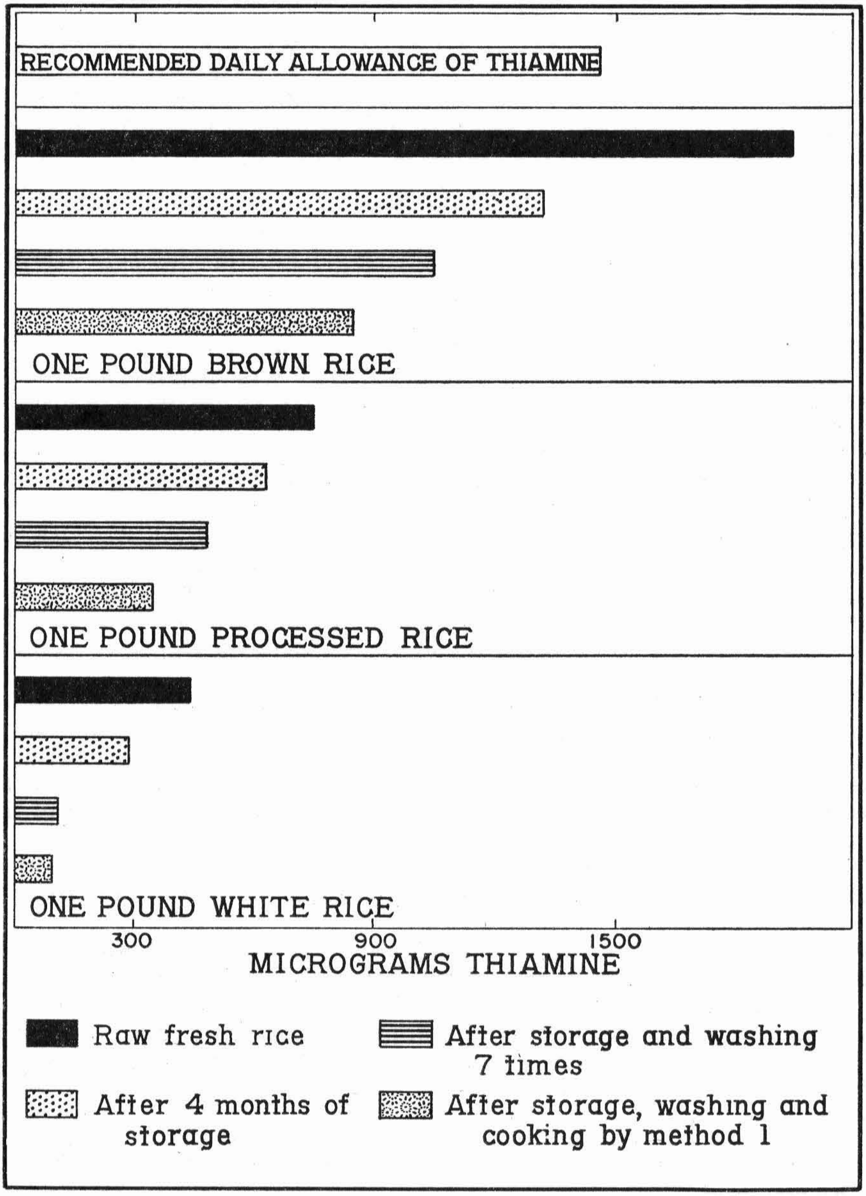

Figure 2.—The recommended daily allowance of thiamine and the thiamine contents of 1 pound of brown, white, and processed rice following storage, washing, and cooking.

more than the day's allowance in the brown rice, one-third in the processed rice, and one-fifth in the white rice. After cooking by methods which discard the cooking water, however (see Method 5, p. 56), the brown rice supplies less than two-thirds of the day's allowance, the processed and white rice about one-fourth.

Brown rice which has been stored 4 months, then washed seven times and cooked without discarding the cooking water, as is the common practice in Hawaii, would supply more than half the required amount of thiamine, processed rice one-fifth, and white rice about one-twentieth.

The decrease in the thiamine content of rice caused by different treatments is shown in figure 2. The thiamine contents of 1 pound of brown, white, and processed rice are compared to the daily recommended allowance. As the rices are stored, washed, and cooked, they lose increasingly more thiamine, until the contribution of 1 pound of white rice is close to zero. It is easy to understand the occurrence of beriberi among people who eat large amounts of white rice and whose practice is to wash the rice thoroughly.

AVAILABILITY OF THIAMINE IN PROCESSED RICE

The physiological availability of the thiamine in rice is an important consideration. In addition to the possible losses, previously discussed, in storing, washing, and cooking, there may also be loss from incomplete vitamin absorption from the intestinal tract or because of other physiological factors.

That the thiamine in processed rice is available to rats has been demonstrated in this laboratory.[4] In the study reported here human subjects were used to determine availability and to demonstrate the effect of processed rice on the nutrition of human beings as evidenced by urinary excretion of thiamine.

It is agreed that for normal subjects on adequate intakes the excretion of thiamine is proportional to the intake, although the exact percentage of the intake excreted will vary from one individual to another and from one day to another (*44*). Parsons, Williamson, and Johnston (*54*) have demonstrated an increase in urinary excretion in response to adding a food to an otherwise constant diet and have assumed that this increase reflects the absorption of the thiamine furnished by that food.

The plan of this study was to feed human subjects a basal diet in addition to large amounts of white rice and to determine the excretion of thiamine on this diet, and then to feed the same basal diet but substitute processed rice for the white rice. If the excretion of thiamine increased we could conclude that the larger excretion reflected the presence and availability of a larger amount of thiamine in the diet.

First Study

Procedure

Three subjects were observed for 11 days. The subjects were Caucasian women, 31 to 34 years of age, in good general health.

Diet: For 3 days, the subjects ate self-chosen diets but took no vitamin prepa-

[4]Thirteen animals, depleted of thiamine stores, then fed 5 grams processed rice daily, showed a mean gain of 27 grams in 3 weeks. Depleted rats, not fed the rice, showed marked loss of weight and 50 percent mortality in the same time.

rations of any kind. Their exact intake of thiamine for these 3 days is unknown.

For the following 4 days they ate, in the Nutrition Laboratory, a diet consisting largely of white rice with a few other low thiamine foods. Each subject ate 750 grams of cooked white rice (corresponding to 350 grams raw weight). One cup of milk, 2 tablespoons of cream, two servings of fruit, and one serving of canned fish or chicken were included every day. Small amounts of pickles, olives, and cottage cheese and unlimited amounts of butter, sugar, and artificial lemonade were permitted. A sample menu is given in Appendix III. Foods used in large amounts were analyzed for their thiamine content in this laboratory. Published thiamine values were used for foods of low thiamine content which were included in small amounts. The average daily intake of thiamine per subject was 250 micrograms.

For the next 4 days each subject ate 950 grams of cooked processed rice (equivalent to 350 grams raw weight). Other foods permitted were the same as during the preceding 4 days on the white rice diet. The average daily intake of thiamine per subject during this period was 520 micrograms.

At the evening meal of the last day a 5-milligram test dose of thiamine was taken.

Collection of urine: Twenty-four-hour urine samples were collected by each subject in brown glass bottles containing toluene and acetic acid. Feces were not analyzed because it has been shown that thiamine from food is excreted in the urine, while that in the feces results from synthesis by bacteria in the intestine and is not usually absorbed (*72*).

Method of analysis: Foods to be analyzed were combined with water in a Waring Blendor, and aliquots of this suspension were analyzed in the manner described on page 11. Aliquots of the urines, after having the *p*H adjusted to 4.5, were adsorbed on Decalso. Known amounts of thiamine were added to a second aliquot of each urine to serve as a standard. Subsequent steps in the analysis were the same as for the foods.

Results

A detailed record of the intake and excretion of thiamine by each subject is given in table 9. The excretions of subjects 1 and 2 on their self-chosen diet indicate that these subjects had adequate thiamine intake. Published criteria for judging thiamine nutrition agree that excretion of over 100 micrograms daily indicates adequate intake (*26, 27, 39, 42, 43, 53*). Subject 3 would be judged borderline by some criteria (*42, 43*). Mickelsen, Caster, and Keys (*44*) have pointed out that there are large individual differences in thiamine excretion.[5]

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[5]Urine samples, collected during the first 4 hours of the day from Caucasian and Oriental subjects, were analyzed for thiamine in this laboratory. Two Caucasian subjects excreted 9 micrograms and 22 micrograms in 4 hours. Four Oriental subjects excreted 2, 5, 13, and 41 micrograms. One Caucasian and three Orientals would be considered deficient or borderline according to the work of Papageorge and Lewis (*53*), who have considered 4 micrograms per fasting hour to be the critical excretion. When these subjects were given a test dose of 1 milligram, the two Caucasians excreted 15 percent and 44 percent in 4 hours and the Orientals 4, 27, 34, and 44 percent. According to Melnick and Field (*42*), only one of these subjects, an Oriental, would be considered deficient on the basis of percentage return of the test dose. We observed no correlation between daily excretion and percentage return of the test dose. Some of those who showed the lowest basal excretion gave high percentage return of the test dose.

TABLE 9. Excretion of thiamine by human subjects in response to different intakes.

DAY	DAILY INTAKE IN MICROGRAMS	DIET	DAILY EXCRETION IN MICROGRAMS		
First Study			Subject number		
			1	2	3
1	unknown	self-chosen	510	344	48
2			277	196	84
3			303	199	65
4	250	white rice	195	118	35
5			101	52	24
6			84	55	14
7			61	130	36
8	520	processed rice	61	91	21
9			53	65	21
10			41	70	20
11	5530	processed rice + 5000 micrograms thiamine	347	583	170

DAY	DAILY INTAKE IN MICROGRAMS	DIET	4	5	6	7	8	9
Second Study								
1	807	white rice	146	298	65	110	113	168
2	780		108	221	26	142	93	83
3	805		141	218	46	131	140	124
4	795		123	197	0	103	85	52
5	798		111	159	16	84	70	46
6	803		99	237	33	57	57	54
7	802		87	125	0	69	50	70
8	1047	processed rice	100	189	17	107	73	59
9	1020		179	181	36	93	62	54
10	1045		162	150	18	89	64	73
11*	1035		...	...	..	...	...	...
12	1038		230	100	0	95	101	117
13	1043		262	267	57	122	70	147
14	1040		177	195	30	158	92	107

*Analyses of this day's urine samples could not be done because of mechanical difficulties with the fluorometer.

When the change was made to the white rice diet the fall in the excretion of thiamine was immediate and pronounced for all three subjects. The excretion of subject 1 continued to fall during the 4 days of this diet; there was an unexplained rise in the excretions of subjects 2 and 3 on the fourth day. Mickelsen and others (*44*) have also pointed out that there are daily variations for the same subject even on constant intake.

When the change was made to the processed rice diet with an intake of 520 micrograms the excretions of all three subjects continued to fall or remained stationary instead of rising again as we had expected. This evidence supports the contention of Mickelsen, Caster, and Keys (*44*) that at intakes less than 700 micrograms the excretion approaches 0. During this period all subjects were excreting less than 100 micrograms daily, considered by some workers (*42, 43*) to indicate insufficient thiamine intake. Subject number 3 would be considered deficient by almost any criteria (*27, 33, 42*). In response to the test dose, subject 3 returned only 3 percent; subject 1, 6 percent, which was lower in amount than her excretion on the first day of her self-chosen diet and indicated a lowered amount of thiamine in the body reserves; and subject 2 returned 11 percent, which is within the range of normal excretion of the test dose reported by others (*26, 43*). These data are reported here because they appear to furnish further evidence that intakes of 520 micrograms or less are not sufficient to permit normal urinary excretion of thiamine.

For the purposes of our experiment we had failed to show a difference in thiamine excretion in subjects on a white rice diet and on a processed rice diet. We concluded that the levels of intake at which we had been working were too low. Accordingly a second study was planned, similar to the first, but one which would use higher levels of intake of thiamine.

Second Study

Procedure

The plan of the second study was much like the first. Six subjects were observed for 14 days. The subjects included three Japanese women (numbers 4, 5, and 7), one Caucasian woman (number 8), and two Caucasian men (numbers 6 and 9). Their ages varied from 24 to 32. All were in good general health.

Diet: Self-chosen diets were not studied in this experiment. A week's menus were planned to include 375 grams dry weight of rice each day. These menus were used the first week with white rice. They were repeated the second week, using processed rice. The intake of thiamine for each subject was planned to be about 620 micrograms in addition to that furnished by the rice. Although this varied slightly from day to day (596 to 662), the intake for each day was definitely known. All foods used were chemically assayed for thiamine and the individual portions were weighed out. A list of the foods used and a typical menu are given in Appendix III.

The intake of thiamine for each subject was 780 to 807 micrograms daily during the week on the white rice diet and was 1,020 to 1,047 micrograms during the week on the processed rice diet.

The diet supplied about 2,000 calories per day, exclusive of butter. The calorie intake was purposely kept as low as possible in order to promote appetite. All of the subjects maintained their weight during the experiment.

Collection of urine: Twenty-four-hour urine samples were collected by each subject in the same manner as in the first study.

Method of analysis: Foods and urines were analyzed in the same manner as in the first study (see p. 32).

Results

Intakes and excretions of the six subjects (numbers 4 to 9) are shown in table 9. Subject number 5 had been taking vitamin pills containing thiamine prior to the experimental period. Only one of the subjects, number 6, showed an excretion of less than 100 micrograms the first day. All subjects showed a decrease of thiamine excretion during the 7 days on the white rice diet. On the seventh day only the subject who had previously taken vitamin pills was excreting more than 100 micrograms daily. This result supports the conclusion of Gifft and Hauck (*26*) that 2 weeks or more are required for a subject to return to a normal excretion level after periods of high intake. Subject number 6 showed very low excretion, 0 on 2 days. These data indicate that 800 micrograms daily are an inadequate intake as evidenced by urinary excretion of thiamine.

When the change was made to processed rice, the intake of thiamine was increased to 1,040 micrograms daily. At this level of intake there was a definite increase in excretion for every subject. Since time is required for the body to adjust to a new level of thiamine intake (*26, 33, 43, 44*) the excretion on the last days of each period is more representative of the response to the intake than the first days. To compare the excretion in response to the two rices, data from the last 3 days of each period were combined to form table 10. It is seen in this table that the excretion for each subject definitely increased on the processed rice diet. In two instances it more than doubled. Four of these subjects were excreting more than 100 micrograms daily on the processed rice diet.

TABLE 10. Comparison of the excretion of thiamine by human subjects on two rice diets.

SUBJECTS	TOTAL EXCRETION OF THIAMINE IN 3 DAYS	
	WHITE RICE DIET	PROCESSED RICE DIET
	Micrograms	*Micrograms*
4.	297	669
5.	521*	562
6.	49	87
7.	210	375
8.	177	263
9.	170	371

*This subject had been taking vitamin pills containing thiamine prior to the experimental period.

The trends in thiamine excretion observed in this study indicate that if the white rice diet had been continued for several weeks, the excretions of all subjects would have stabilized at levels near 0. If the processed rice diet had been continued a sufficient length of time, the excretion would have stabilized at a higher level. Since we were interested in observing the direction of the changes rather than the exact amount of the excretion, we did not feel that it was necessary to continue the experiment until excretion was constant.

Conclusion

Six subjects who were changed from a self-chosen diet to a high white rice diet showed a decrease in thiamine excretion. When processed rice was substituted for white rice in the diet, the decrease was stopped and a rise in thiamine excretion began. It can be concluded that the increased excretion reflects the availability of the thiamine in the processed rice and demonstrates an improvement in thiamine nutrition caused by substituting processed rice for white rice in the diet.

SUSCEPTIBILITY OF BROWN, WHITE, AND PROCESSED RICE TO INSECT INFESTATION

by Yoshinori Tanada

The condition of rice during and after storage is of great importance to the grocer and to the consumer. Because grocers are reluctant to keep in stock foods which have a slow turnover and which are liable to spoilage or insect infestation, brown rice is not always available in grocery stores in Hawaii.

Brown rice, which is husked but otherwise untreated, has been observed to be more susceptible to insect attack than white, polished rice. Brown rice has higher thiamine and niacin contents than white (see table 1, p. 13). Fraenkel and Blewett (*21*) have reported from their study of several insects in stored products that all the species they observed seem to require vitamins of the B-group. Balzer (*8*) has stated that nearly all rice pests prefer brown to milled rice. Kunike (*37*) has found that 100 individual rice weevils produced in 3 months 476 progeny in untreated husked rice, 15 in polished rice, and 15 in glazed rice.

If processed rice is less susceptible to insect attack than brown, it might be more acceptable to grocers. Mickus (*45*) reported that when 100-gram lots of 16 types of rice were infested with 50 adults each of the rice weevil, the granary weevil, the lesser grain borer, and the red flour beetle, processed rice showed more resistance to these four species than brown and some samples were more resistant than white rice.

A study was undertaken at this Experiment Station to determine the relative amount of insect infestation of brown, white, and processed rice under typical Honolulu storage conditions.

PROCEDURE

Eighteen 100-pound sacks of rice, six each of brown, white, and processed, were stored for 4 months in two Honolulu warehouses. For the general plan of the storage experiment and description of the warehouses, see pages 15 to 16.

The rice was sampled before storage and at intervals of 4 weeks during the 4-month storage period. Two samples were taken from each bag with a grain sampler, one through the center and one from the side.

In the first two samplings each sample was obtained with one scoop of the sampler (about 80 grams), while in subsequent samplings, two scoops of the sampler (about 170 grams) made up each sample. The rice was weighed immediately after sampling and all adult insects were removed and counted. To permit the development of immature insects that were present in the rice samples, the rice was stored for about 2 months in screw-top flint glass bottles placed in battery jars covered with cheesecloth. To restrict the emerging insects from reproducing, the samples were examined two or three times during the storage period and all adult insects that had emerged were removed and counted. The number of insects given in the tables represents the total number of adult insects present in a sample from the time of sampling to the end of the storage period.

RESULTS

Ten species of insects were collected from the rice samples during the 16-week storage period. There were two species of moths, six species of beetles, and two species of parasitic wasps. The insects are listed below in the order of their abundance.

ORDER	COMMON NAME	SCIENTIFIC NAME	FAMILY
LEPIDOPTERA (Moths)	Almond moth	*Ephestia cautella* (Walk.)	Phycitidae
	Rice moth	*Corcyra cephalonica* Stn.	Galleriidae
COLEOPTERA (Beetles)	Lesser grain borer	*Rhyzopertha dominica* (Fabr.)	Bostrichidae
	Red flour beetle	*Tribolium castaneum* (Herbst)	Tenebrionidae
	Rice weevil	*Sitophilus oryza* (Linn.)	Curculionidae
	Corn sap beetle	*Carpophilus dimidiatus* (Fabr.)	Nitidulidae
	Flat grain beetle	*Laemophloeus minutus* (Oliv.)	Cucujidae
	Saw-toothed grain beetle	*Oryzaephilus surinamensis* (Linn.)	Cucujidae
HYMENOPTERA (Wasps)	Parasite	*Aplastomorpha calandrae* (How.)	Pteromalidae
	Parasite	*Chaetospila elegans* (Westw.)	Pteromalidae

All the eight species of moths and beetles are known as important pests of stored rice (*8, 16, 19, 24, 30, 66*).

In table 11 the average number of each species of insect found per 100 grams of brown, white, and processed rice during the 16-week storage period is given. In warehouse A fewer insects of all species were found in processed rice than in brown or white. In both warehouses brown rice had the largest number of in-

TABLE 11. The populations of different species of insects in brown, white, and processed rice during 16 weeks' storage in two warehouses.

SPECIES OF INSECTS	AVERAGE NUMBER INSECTS PER 100 GRAMS						AVERAGE OF EACH SPECIES
	Warehouse A			Warehouse B			
	Brown rice	White rice	Processed rice	Brown rice	White rice	Processed rice	
*Ephestia cautella** and *Corcyra cephalonica*	2.0	1.5	1.1	0.4	0.1	0.2	0.9
Rhyzopertha dominica	3.0	0.9	0.8	0	0	0	0.8
Tribolium castaneum	1.4	0.2	0.1	0.1	0.03	0.1	0.3
Sitophilus oryza	0	0	0	1.0	0.5	0.1	0.3
Carpophilus dimidiatus	0.3	0.3	0.03	0.5	0.3	0	0.2
*Laemophloeus minutus** and *Oryzaephilus surinamensis*	0.8	0.4	0.1	0	0.03	0	0.2
*Aplastomorpha calandrae** and *Chaetospila elegans*	0.1	0.03	0	1.4	0	0	0.3

*More abundant of the two.

sects. In warehouse B, processed rice had a larger population of the almond moth and the red flour beetle than white rice but a smaller population of all other species.

In warehouse A, the almond moth, *Ephestia cautella,* predominated, and there were no weevils reared from any of the different types of rice; in warehouse B, the rice weevil, *Sitophilus oryza,* was most abundant and there were relatively few moths. The lesser grain borer, *Rhyzopertha dominica,* was also quite abundant in warehouse A but was not present in warehouse B. The red flour beetle, *Tribolium castaneum,* was fairly abundant, but the corn sap beetle, *Carpophilus dimidiatus,* the flat grain beetle, *Laemophloeus minutus,* and the saw-toothed grain beetle, *Oryzaephilus surinamensis,* occurred less frequently. Two species of wasps, *Aplastomorpha calandrae* and *Chaetospila elegans,* reported as parasites of the rice weevil, were collected from the rice samples from both warehouses although no rice weevil was reared from the samples of warehouse A.

In table 12 is shown the average number of moths and beetles recovered from brown, white, and processed rice at the end of 4, 8, 12, and 16 weeks of storage. No insects were found in any of the rice samples at the beginning of the experiment. During the first month of storage, the number of moths increased rapidly in the rice stored in warehouse A, even though spraying with pyrethrum twice a week was practiced, but subsequently the number declined until at the last sampling, only one-sixth as many were found as at the second sampling. A similar variation in the abundance of moths had been noticed in a preliminary study using one sack of processed rice. The beetles, on the other hand, increased gradually in numbers and were the predominant insects during the last 4 weeks of storage. At each sampling, as shown in table 12, processed rice showed much less insect infestation than brown and slightly less than white.

TABLE 12. The average number of moths (Lepidoptera) and beetles (Coleoptera) recovered from brown, white, and processed rice during 16 weeks' storage in two Honolulu warehouses.

	BROWN RICE		WHITE RICE		PROCESSED RICE	
	No. moths per 100 gm	No. beetles per 100 gm	No. moths per 100 gm	No. beetles per 100 gm	No. moths per 100 gm	No. beetles per 100 gm
Weeks of storage in Warehouse A						
0........	0	0	0	0	0	0
4........	7.2	2.4	4.3	0.8	4.1	0.4
8........	0.2	4.8	0.3	1.7	0	0.5
12........	0.3	5.1	0.6	1.4	0	0.5
16........	0.4	9.4	0.9	2.7	0.1	2.8
Weeks of storage in Warehouse B						
0........	0	0	0	0	0	0
4........	0.7	0.2	0.2	0	0	0
8........	0.4	0.6	0.1	0.3	0.1	0.1
12........	0.5	2.2	0	0.9	0.1	0.1
16........	0.1	3.2	0.1	2.4	0.5	0.6

TABLE 13. Distribution of moths (Lepidoptera) and beetles (Coleoptera) in 100-pound sacks of rice during 16 weeks' storage in warehouses.

LOCATION	KIND OF RICE	AVERAGE NUMBER OF INSECTS PER 100 GRAMS OF RICE				
		Lepidoptera		Coleoptera		Average
		Side	Center	Side	Center	
Warehouse A	Brown	2.3	1.8	5.3	5.6	3.8
	White	2.0	1.1	0.7	2.6	1.6
	Processed	1.5	0.6	0.9	1.2	1.1
	Average	1.9	1.2	2.3	3.1	
Warehouse B	Brown	0.5	0.3	1.3	1.8	1.0
	White	0.1	0.1	1.3	0.5	0.5
	Processed	0.1	0.2	0.2	0.2	0.2
	Average	0.2	0.2	0.9	0.8	

The changes in total insect infestation, the decrease in thiamine content, and the mean and low humidity and temperature of the warehouses during the 16-week storage period are shown in figure 1, page 16.

In table 13 is given the insect population in two different parts of the bag of rice. In warehouse A, the moths were present in greater numbers along the side of the bag than in the center, whereas the beetles were slightly more abundant along the center than the side. In warehouse B, there appeared to be no difference in insect population in the two parts of the bag.

DISCUSSION

The lesser susceptibility of processed rice to insect infestation may be due to vitamin content, moisture content, or hardness of the grain. Although processed rice has a lower thiamine content than brown rice, it is much higher in thiamine than white rice. Processed rice and brown rice both have a decidedly greater niacin content than white rice. Since the processed rice showed much less susceptibility to insect infestation than the brown rice, and slightly less than white, thiamine or niacin content does not seem to be the major determining factor.

The data on the moisture content of the three different kinds of rice (table 1, p. 13, and table 2, p. 17) indicate that processed rice has a significantly lower moisture content than brown and white rice. The insects of stored products require a certain amount of moisture in the grain for their development. The rice weevil (*10, 25, 45*) and the corn sap beetle (*9*) will not breed in grain containing less than 10 percent moisture. The lesser grain borer, *Rhizopertha dominica,* requires a moisture content greater than 8 to 9 percent (*10, 25*). While none of the samples of processed rice assayed contained less than 8 percent moisture, the generally lower moisture content of the processed rice may have been a factor in lessening susceptibility to insect infestation.

Hardness of the rice is related to its moisture content. At a high relative humidity, the rice grains absorb moisture and become softer. The process of parboiling increases the hardness of rice (*1, 64*). In British Guiana the larval period of the rice weevil has been found to increase with the hardness of the rice grains (*1*). Mickus (*45*) has advanced the explanation that processed rice has such a hard surface that it cannot be penetrated by the mandibles of the weevils. The hardness of the grain may have been largely responsible for the low susceptibility of processed rice to insect infestation observed in this study.

The number of insects found and the predominant species were different in the two warehouses. The factors probably responsible for these differences were light, temperature, and humidity. In warehouse A, where the moths were more abundant and destructive, the rice was stored in semi-darkness, under a higher mean temperature and lower but more uniform relative humidity (table 2, p. 17). The lighter and more open condition of warehouse B appeared to be unfavorable to the moths. The rice weevil, *Sitophilus oryza,* was the insect of major importance in warehouse B. Other possible factors influencing the difference in insect population of the rice in the two warehouses may have been the storage and movement of other infested cereals.

The control of insects in stored rice, although not undertaken in the present study, is of great practical importance. The usual recommendation for the control of insects in stored products is the application of sanitary measures in the warehouses and the fumigation of the stored rice (*7, 8, 14, 29, 66, 67*). Some workers have obtained promising results by packaging food products in insect-proof bags made of paper, and by the use of repellents or toxicants on these bags (*17, 20, 23, 38, 67, 68, 69*). With proper packaging and fast turnover in warehouses processed rice could be delivered to the Hawaii consumer almost insect free.

SUMMARY

The susceptibility of brown, white, and processed rice to insect infestation was studied by observing 18 100-pound sacks of rice for 4 months under Honolulu warehouse conditions. Two species of moths, six species of beetles, and two species of parasitic wasps were collected from the rice during this period and identified.

The number of insects found per 100 grams of brown rice was considerably greater than that found in the other kinds. Processed rice appeared to be slightly less susceptible to insect infestation than white rice. This lower susceptibility of processed rice may be due mainly to its lower moisture content and the hardness of the grains.

There was more insect infestation in the rice stored in semi-darkness, under a higher mean temperature and lower but more uniform relative humidity.

The low susceptibility of processed rice to insect infestation is of great practical importance to distributors and consumers of rice. With insect-proof packaging and minimum periods of storage it should be possible to deliver processed rice to the Hawaii consumer practically insect free.

CONSUMER ACCEPTABILITY OF PROCESSED RICE
by Winifred R. Vinacke, John Rademaker, and Margaret Chave

The question of consumer acceptability is of great importance. The nutritive value of processed rice has been shown to be higher than that of white; processed rice stores well; it is not as subject to insect infestation as brown rice. However, these advantages are of little value if the consumer cannot be induced to use the rice.

Methods of measuring consumer acceptance are still being developed. Bulletin 111 of the National Research Council (*50*) summarizes work done on methods of studying food habits and gives a comprehensive bibliography on the subject.

The objectives of a food habit study are to determine (1) the food habits of a group of people and (2) how these food habits may be influenced to accord with good nutritional practices. In this study we wanted to know (1) to what extent brown and white rice are used in the Territory, (2) the consumers' opinions on processed rice compared with brown and white, (3) the reasons for preferring one kind of rice to another, and (4) whether brown or processed rice would be more acceptable as a substitute for white.

Two methods were used in this laboratory to obtain answers to the above questions: (1) Plate waste of brown, white, and processed rice was observed in school cafeterias and the amounts of discarded rice compared; (2) families were interviewed before and after they had used the processed rice and their opinions and comments were tabulated.

A STUDY OF PLATE WASTE IN SCHOOL CAFETERIAS
by Winifred R. Vinacke

Plan

With the cooperation of seven cafeteria managers in the public schools,[6] plans were made to observe the plate waste of brown, white, and processed rice under conditions as nearly alike as possible. The managers planned to serve the same menu—stew and rice—at least six times during the school year. Although other items on the menu were the same, the rice might be brown, white, or processed. Each time, the rice left on the plates was to be collected and weighed. The amount of rice served was to be measured in the kitchen and the numbers of customers taking rice and discarding rice were also to be counted. By comparison of these data for the three kinds of rice, a rough estimate of their relative acceptability could be obtained.

Table 14 describes the schools used for this study. Particular groups of customers to be observed were selected at different age and educational levels and in schools in different parts of the city.

In schools where lunch was eaten in the classroom, only a few groups could be studied. At the schools which served in the cafeteria, workers could stand at the scraping table and thus check the plates of all the customers. Schools serving in the classroom gave no choice of food, but served a plate lunch. Those serving

[6]Under the direction of the Territory of Hawaii Department of Public Instruction, Home Economics Department.

TABLE 14. Type of school and food service, number of customers, and description of group studied in seven school cafeterias.

SCHOOL DESIGNATION	TYPE OF SCHOOL	LOCATION WHERE NOON MEAL IS EATEN	APPROXIMATE NO. OF CUSTOMERS	GROUPS STUDIED
A	Grade school	Classroom	60	3 first-grade rooms
B	Grade school	Classroom	110	3 first- and 2 second-grade rooms
C	Grade school	Classroom	55	3 rooms, including third, fourth, fifth, and sixth grades
D	Grade school	Cafeteria	90	1 fifth-, 1 sixth-, and 2 fourth-grade rooms
E	Junior high school	Cafeteria	235	Seventh, eighth, and ninth grades
F	Vocational high school	Cafeteria	200	Entire student body
G	University	Cafeteria	900	All customers

in the cafeteria gave no choice of hot plate, but in schools E and F the customer could select sandwiches or salad in addition to or instead of the hot plate. In school G, which gave a choice of hot plate and cold plate every noon, it was possible to count the total number of customers and also the number selecting rice.

Methods

The amount of rice served was measured by weighing the large serving dish of rice on a pound scale before and after the serving period. Most of the scales used measured only to the nearest ½ pound. A few measured accurately differences of ¼ pound.

The number of customers served was determined in different ways: (1) The observer stood at the serving table or cash register and counted the plates of rice as they came by; (2) the number of serving plates was counted before and after the serving period; or (3) the actual number of plates was counted in the school room or at the assigned table in the lunchroom. In schools F and G the second method was used. In the other schools, two counts were made as a check on each other.

The number of customers discarding rice was counted by an observer standing by the scraping table or by the lunchroom table if the plates were scraped there. It was necessary for the observer to decide whether a few grains of rice on a plate were overlooked by the customer or constituted an actual refusal. This was the most subjective of the measurements. As a rough guide, amounts which appeared to be 5 grams or more were considered refusals.

Rice discarded was collected by a worker standing at the scraping table. When a plate containing refused rice came to the scraping table, the worker separated the rice from the other refuse with a rubber plate scraper and collected the rice only in a special can. These cans were returned to the Nutrition Laboratory and weighed.

At school D a different method of measuring the amount of discarded rice was used. All of the refuse on the plates was collected and returned to the Nutrition Laboratory where the rice was separated from the rest of the garbage and weighed. This method has the advantage over the first of being more accurate. The worker does not have to decide which plates to scrape; all the rice discarded is measured; sometimes when the number discarding had been counted as zero, an appreciable amount of rice was found in the garbage, an accumulation of a few grains of rice from many plates. This method has the disadvantage of being very time consuming. Each time, 3 hours were needed to separate the garbage left by the 90 customers of school D.

Limitations of the methods

There are certain difficulties inherent in this type of study. Measurements of rice served and the number of people served must be made in the hurry of a lunch-serving period, often by several different people. If errors are made, there is no chance for correction later.

Where the study was made in the classroom, the children were quite conscious of the presence of the observer and may not have eaten in the normal manner. Many schools have been serving brown rice for years and have made a distinct effort to encourage the eating of brown rice. Some schools have insisted that the child eat everything on his plate. These children would have a tendency to eat any kind of rice at school, even though they might not do so at home.

In plate scraping there were inevitable inaccuracies. Even in the method used in school D and more certainly in the method of separating the rice from the other refuse at the scraping table, it was impossible to scrape a plate quantitatively in the rush of a school cafeteria plate-scraping line.

In addition to these limitations are the presence of any number of uncontrollable factors which also influence plate waste. Although we are using plate waste to measure acceptability there may be other reasons why a child leaves rice on his plate today but not tomorrow. Fluctuations in the child's health, what he had for breakfast, the activities of the morning, the weather, the discipline of the teacher, and other factors also influence the amount and kind of food the child eats.

Despite these limitations it is still desirable to develop methods for measuring consumer acceptance. The study of plate waste may prove effective if some of the above difficulties can be minimized and if it is borne in mind that the results are not strictly quantitative but rather indicative of several factors including acceptability of the food.

Results

Table 15 shows the total number of customers observed in each school, the percentage of rice discarded, and the percentage of customers who left rice on their plates. The amount of rice discarded per customer served and per customer discarding has also been calculated and is shown in this table.

The figures on percentage of rice discarded show least discard of white rice in five schools out of seven. One of the schools shows least discard of brown rice, another, least of processed. Highest discards are of brown in one school, processed in six schools. These figures indicate that white rice is more acceptable than the

TABLE 15. Brown, white, and processed rice discarded in school cafeterias.

SCHOOL	KIND OF RICE	NUMBER OF OBSERVATIONS	TOTAL NO. CUSTOMERS	PERCENTAGE OF RICE DISCARDED	PERCENTAGE OF CUSTOMERS DISCARDING	GRAMS RICE DISCARDED	
						Per customer served	Per customer discarding
A	Brown	2	112	0.4	5.4	0.2	3.3
	White	2	115	0	0	0	0
	Processed	2	120	2.2	5.8	1.1	19.4
B	Brown	2	208	17.5	41.3	10.0	24.3
	White	2	212	13.8	. . .	8.6	. . .
	Processed	2	187	12.1	42.3	9.2	21.8
C	Brown	2	113	1.3	6.2	1.1	17.5
	White	2	112	0.4	3.6	0.3	8.5
	Processed	2	97	1.7	3.1	1.4	46.9
D	Brown	3	276	8.9	9.1	5.6	61.8
	White	3	261	6.2	8.1	3.9	48.7
	Processed	4	374	11.5	10.7	5.5	51.7
E	Brown	2	579	11.7	. . .	10.9	. . .
	White	2	438	6.5	. . .	5.6	. . .
	Processed	2	481	19.4	. . .	9.9	. . .
F	Brown	2	386	7.1	11.9	6.5	53.1
	White	1	203	2.4	6.4	2.2	34.9
	Processed	2	416	8.0	20.4	7.8	38.2
G	Brown	4	3365	6.0	21.0	6.2	29.4
	White	3	2656	7.0	20.3	6.7	32.7
	Processed	3	2457	7.8	22.1	6.5	29.4

others and that brown is slightly more acceptable than processed. This might be expected, since white rice is a common staple food for many of these students and processed rice is a much newer product than brown.

Another factor should be mentioned: Because processed rice is not sticky, the servings as dished out by a standard serving scoop tend to be smaller than those of white or brown rice. Because it does not stick together on the plate it is easy for every customer to miss a few grains. This tends to make the total waste slightly higher and to make the same amount of waste calculate as a higher percentage. For this reason the grams of waste per customer served and per customer discarding were calculated.

Grams of waste per customer served are shown in table 15. Although white rice is still preferred, the differences between the rices are smaller; according to these figures brown rice and processed rice are equally acceptable.

The grams of waste per customer discarding, as shown in table 15, are usually quite large, indicating that those who left rice at all left large amounts of it. The discard per customer for processed rice was the same as or less than that for brown in four out of six schools and was less than that for white in one school. From this point of view, processed rice is slightly more acceptable than brown.

The percentage of customers discarding rice gives a rougher estimate of acceptability because of the difficulty of drawing the line between a few grains accidentally left on a plate and an actual refusal to eat all the rice. According to these figures white rice is preferred and brown and processed rice are about equally acceptable.

The differences between the schools are much larger than the differences between the rices in any one school, as can be seen in table 15. This fact would indicate that the factors other than acceptability that influence plate waste varied from school to school and exercised considerable influence. Each school must be considered as a unit in comparing the acceptability of the rices.

School G, the University Cafeteria, has served brown rice whenever available in th past, and its clientele has become accustomed to it. The percentage selecting rice could be observed in this cafeteria, as the customers had a choice of the complete hot plate, hot plate without rice, and cold plate. Eighty-four percent of the customers selected brown rice on the days that it was offered, 85 percent selected white rice, and 86 percent processed. By this criterion, the three rices were equally acceptable. In table 15 it can be seen that when measured by percentage of rice discarded or percentage of customers discarding, the acceptability of the rices is still the same. Thus, by any standard of measurement, in the largest school studied and the one at the highest educational level, the customers ate well any rice that was served to them.

In school D it was possible to observe the plate waste of rice before and after a study unit on processed rice was presented in the classroom. Four rooms were observed in this school, two fourth grades, a fifth grade, and a sixth grade. In one of the fourth grades, 2 weeks were devoted to a discussion of processed rice and to developing a project as a result. The method of processing was described and discussed, and mention was made of the use of processed rice by the army. The advantages of processed rice were stressed: it stores better; it does not need to be washed; it has more vitamins—especially thiamine—and minerals than white rice.

A great deal of interest was shown by the children. They were interested in the idea that it was new, that it was better, that it had been used by the army. As

TABLE 16. Grams of rice discarded per customer served in four school rooms before and after a classroom study of processed rice.

ROOM	BROWN RICE		WHITE RICE		PROCESSED RICE	
	Before	After	Before	After	Before	After
	Gms	*Gms*	*Gms*	*Gms*	*Gms*	*Gms*
1	4.3	5.4	3.0	4.0	3.7	3.5
2	5.4	9.0	3.4	3.8	5.3	4.8
3	4.0	1.7	4.8	4.1	3.9	3.8
4	7.7	6.0	4.6	3.7	6.9	9.6

a result, they suggested and planned a program for presenting their information to the other intermediate grades in the school.

Plate waste did not change significantly as a result of the educational program. The grams discarded per customer served for each room studied in school D are shown in table 16. Room 1 is the fourth grade that presented the program; room 2 the other fourth-grade room; 3 and 4, the fifth and sixth grades, respectively. Although in three rooms the plate waste of processed rice decreased immediately after the classroom study, in the other room it increased noticeably. Waste of brown rice went up in two rooms, down in two, as did waste of white rice. As in table 15, the differences between the groups of children are greater than the differences between the rices. While this tabulation does not show the expected carry-over from the classroom to the lunchroom, the data are presented because they may be of interest to others attempting this type of study.

Summary

Plate waste of brown, white, and processed rice has been observed in seven school cafeterias. A total of 13,062 plates were observed during 48 serving periods. The weight of the rice served and discarded, the number of customers served, and the number discarding rice were recorded. Tabulation of these figures revealed that white rice is more acceptable than either brown or processed, a result which we expected, because white rice is habitually served in most Oriental homes. Brown and processed rice appear to be equally acceptable. The differences between the rices were less than the difference between schools.

Despite limitations, the study has been useful in demonstrating that processed rice is acceptable in the school cafeteria. The waste of processed rice was in no instance excessive and many times was as low as that of white rice. Often the children did not seem to be aware that there was any difference in the rice. In general customers in cafeterias will eat without question any rice that is served to them.

The results of this study indicate that habit plays an important part in food preferences. The schools have the opportunity of influencing the food habits of their students by consistently serving brown or processed rice in the cafeterias.

A STUDY OF CONSUMER ATTITUDES

by Winifred R. Vinacke, John A. Rademaker, and Margaret Chave

To determine the reactions of consumers to processed rice, a series of interviews was planned with a group of families which would be representative of Honolulu's population.

Families

Names of 200 families to be interviewed were selected from the most recent (1943) Office of Civilian Defense census. The names were selected in such a manner that the list would be a representative sample of the population of Honolulu. Families were selected from all parts of the city, with different racial backgrounds and occupations represented in the same proportion as they occur in the population according to this census. This plan for a representative sample of the population of Honolulu is shown in Appendix IV (p. 60). The families are classified by racial ancestry and occupational group.

Method of Interviewing

The interviewing was done by 111 junior and senior students in a university sociology class in "The Family." Detailed instructions were given in class on how to conduct an interview. Individual help was given where needed. Each interviewer visited two families, taking with him a package of processed rice, large enough to furnish one meal for the family, and mimeographed instructions for cooking it. The processed rice, freshly arrived from California, was purchased in 100-pound burlap bags and repacked in small paper sacks in the laboratory. The interviewer explained to a member of the family that the purpose of the interview would be to get their opinions about the rice. The person interviewed was usually the homemaker of the family, who gave her own opinions and reported the reactions of her family. Each family was visited a second time by the same interviewer and the homemaker was questioned about the rice, answers being recorded on a mimeographed questionnaire, a copy of which is shown in Appendix V. If the interviewer was not able to locate the specific family to which he was assigned, he selected another family similar in size, racial background, and occupation in the same neighborhood.

Tabulation of Questionnaires

A total of 209 questionnaires were completed and returned to the laboratory. Nine of these were discarded to make the questionnaires used conform more nearly to the plan shown in Appendix IV. A summary of the racial backgrounds and occupations of the families actually interviewed is also given in Appendix IV (p. 60). The 12 "Others" include four Caucasian-Japanese, three Chinese-Japanese, two Korean, and one each of Puerto Rican, Chinese-Puerto Rican, and Filipino-Caucasian. There were fewer Caucasian families interviewed than planned for, but this discrepancy was not believed serious as it reflects an actual change in the population of Honolulu since 1943. Although the interviews as summarized may slightly over-emphasize the Oriental population, they are the rice-eating group and, therefore, the group in which we are most interested for the purposes of this study.

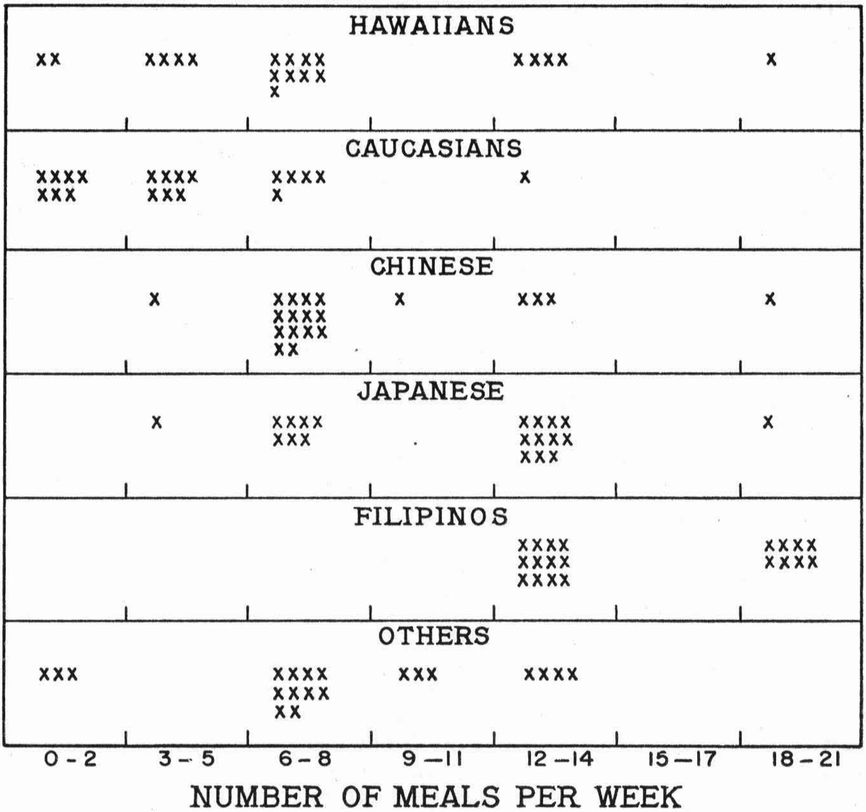

Figure 3.—The number of meals per week at which rice is served by Honolulu families of various racial ancestries. Each cross symbol represents 5 percent of the families in the racial group in which it appears.

A total of 928 people tasted the rice to provide the opinions which are presented here.

Results

The results derived from tabulating the answers to the questionnaires are shown in tables 17, 18, 19, 20, and 21 and figure 3.

Size and composition of families

The size and composition of the families studied are shown in table 17. The large majority had three to nine members. Only one person living alone was included in this study—a Chinese. Almost a third of the Chinese families, half of the Japanese, and all the Filipino families had first-generation members. The first-generation members of Oriental families would be expected to prefer white rice.

TABLE 17. Size and composition of 200 Honolulu families studied.

	HAWAIIAN	CAUCASIAN	CHINESE	JAPANESE	FILIPINO	OTHERS	TOTAL
Number of families studied	27	45	30	76	10	12	200
Percentage of families having 2 members	15	13	3*	8	20	8	10
Percentage of families having 3 to 5 members	26	67	67	46	10	50	50
Percentage of families having 6 to 9 members	37	20	27	42	60	42	35
Percentage of families having 10 or more members	22	0	3	4	10	0	5
Percentage of families having first-generation members	..	..	30	49	100	..	..

*Only one person in this family.

Food habits

Food habits of the families, as indicated by the number of meals per week that rice is served, are pictured in figure 3. Most of the families serve rice from three to 14 times per week; 66 percent of the Japanese families and 100 percent of the Filipino families serve rice more than once a day. Rice is used more often in Filipino homes than Japanese, and more often in Japanese than Chinese. This corresponds to the number of families having first-generation members—100 percent of the Filipinos, 50 percent of the Japanese, and 30 percent of the Chinese. Even the majority of Caucasian and Hawaiian families serve rice more than three times a week. These counts may even be a trifle low because in some interviews no questions were asked about the noon meal which was eaten away from home. Two hundred Honolulu families reported rice served at 1,526 meals in a week, an average of 7.6 meals per family per week. These results demonstrate the wide use of rice in Honolulu and emphasize the importance of the nutritive value of rice to the people of the Territory.

Comparisons of the rices

Each interviewee was asked to indicate her opinion of the flavor, texture, and color of processed rice in terms of a comparison with brown and white rice. As indicated in the questionnaire shown in Appendix V, the homemaker was asked whether she thought the flavor of processed rice was better than that of white, the same, or poorer, etc. The answers to this part of the questionnaire are summarized in tables 18, 19, and 20. One-third of the families had no opinion when asked to compare brown and processed rice. Frequently they explained that they had never tasted brown rice.

TABLE 18. Opinions on FLAVOR of processed rice derived from interviews with 200 Honolulu families.

	HAWAI-IAN	CAUCA-SIAN	CHI-NESE	JAPA-NESE	FILI-PINO	OTHERS	TOTAL
Total number families	27	45	30	76	10	12	200
Comparison with white rice							
Percentage liking processed rice better	11	25	13	7	0	34	14
Percentage liking processed rice as well.	7	22	17	16	10	8	15
Percentage liking processed rice less well.	74	47	70	72	90	50	66
Percentage having no opinion	8	6	0	5	0	8	5
Comparison with brown rice							
Percentage liking processed rice better	19	36	40	18	30	42	28
Percentage liking processed rice as well.	33	13	13	16	30	33	19
Percentage liking processed rice less well.	11	27	20	22	10	17	20
Percentage having no opinion	37	24	27	44	30	8	33

Opinions on flavor: Sixty-six percent of the interviewees preferred the flavor of white rice to that of processed rice. When processed rice was compared to brown, however, 70 percent of those having an opinion preferred the flavor of processed rice or liked it as well as brown. Table 18 shows the percentage of families in each group who liked the flavor of processed rice better than, as well as, or less well than that of brown or white. Caucasians and "Others" showed more preference for the flavor of processed rice when compared to white than do the Hawaiian and Oriental groups. When the flavor of processed rice is compared with that of brown, Caucasians, Chinese, and Others show a strong preference for processed. In all groups more families prefer processed rice when it is compared with brown than when it is compared with white rice.

Opinions on texture: Sixty-five percent of the families preferred white rice to processed, but 71 percent of those having an opinion thought that the texture of processed rice is the same as or better than that of brown. Table 19 shows the opinions on texture according to racial groups. Caucasians showed more preference for the texture of processed rice as compared to white than did other groups. When processed was compared with brown, 61 percent of the Chinese having an opinion definitely preferred the texture of processed. Again, in all groups more families preferred processed rice when it was compared with brown than when it was compared with white rice.

Opinions on color: Color seemed to be an important factor in the preference for processed rice as compared with brown. Sixty-three percent preferred the color of white rice, but 82 percent liked the color of processed rice as well as or better than that of brown. In table 20, these opinions are shown according to racial

TABLE 19. Opinions on TEXTURE of processed rice derived from interviews 200 Honolulu families.

	HAWAIIAN	CAUCASIAN	CHINESE	JAPANESE	FILIPINO	OTHERS	TOTAL
Total number families......	27	45	30	76	10	12	200
Comparison with white rice							
Percentage liking processed rice better	11	25	10	4	0	17	11
Percentage liking processed rice as well............	15	27	17	20	20	8	20
Percentage liking processed rice less well..........	67	44	73	71	80	67	65
Percentage having no opinion	7	4	0	5	0	8	4
Comparison with brown rice							
Percentage liking processed rice better	26	38	47	22	30	25	31
Percentage liking processed rice as well...........	30	13	7	13	30	42	17
Percentage liking processed rice less well..........	11	22	23	21	10	25	20
Percentage having no opinion	33	27	23	44	30	8	32

TABLE 20. Opinions on COLOR of processed rice derived from interviews with with 200 Honolulu families.

	HAWAIIAN	CAUCASIAN	CHINESE	JAPANESE	FILIPINO	OTHERS	TOTAL
Total number families......	27	45	30	76	10	12	200
Comparison with white rice							
Percentage liking processed rice better	7	20	10	3	10	8	9
Percentage liking processed rice as well............	22	24	20	17	20	25	20
Percentage liking processed rice less well..........	56	47	67	75	70	50	63
Percentage having no opinion	15	9	3	5	0	17	8
Comparison with brown rice							
Percentage liking processed rice better	41	35	53	26	30	17	34
Percentage liking processed rice as well...........	15	20	17	18	30	50	21
Percentage liking processed rice less well..........	7	16	10	12	10	25	12
Percentage having no opinion	37	29	20	44	30	8	33

group. Caucasians showed some preference for the color of processed rice as compared to white, but the other groups definitely preferred white rice. When the color is compared with that of brown, the Chinese and Hawaiians particularly preferred processed rice, and in all groups the large majority of those having an opinion liked the color of processed rice as well as or better than that of brown.

Since the color of processed rice is noticeably darker than that of white, it is true that the families trying the rice knew that it was new and different. The tasters could expect it to taste different and, therefore, not as good. If the color were not noticeably different, the whole reaction might be more favorable. Some methods of processing yield a lighter colored rice than others. The summaries of the opinions on flavor, texture, and color indicate that white rice is preferred, but that processed is more acceptable than brown.

This conclusion is confirmed by the answers to the question, "Which of the three kinds of rice does your family prefer?" which are summarized in table 21. Eighty-one percent of the families interviewed stated that they preferred white rice; 3 percent preferred brown or mixed brown and white; 12 percent preferred processed or mixed white and processed.

Unsolicited comments on the processed rice, recorded on the questionnaire sheets, also reveal attitudes. Odor was mentioned most frequently, 35 times unfavorably, six times favorably. Texture was next most frequently commented upon; 33 families objected to the texture, stating that it was too dry or not sticky enough. Five liked the texture, stating that it was fluffy and not mushy. Flavor was mentioned seven times favorably, 17 times unfavorably. Color was mentioned only five times, unfavorably, and cooking quality and price were commented on twice. Three families, one each of Filipino, Chinese, and Japanese ancestry, reported that the rice couldn't be eaten with chopsticks. Two Japanese families complained that the rice was not suitable for rice-tea mixture or for *sushi* (a dish made by spreading

TABLE 21. Kind of rice preferred by 200 Honolulu families.

	HAWAIIAN	CAUCASIAN	CHINESE	JAPANESE	FILIPINO	OTHERS	TOTAL
Number of families interviewed	27	45	30	76	10	12	200
Percentage preferring white	85	62	84	91	80	83	81
Percentage preferring brown	0	7	3	0	0	0	2
Percentage preferring mixed brown and white	0	0	3	1	0	0	1
Percentage preferring processed	11	25	0	1	10	17	9
Percentage preferring mixed white and processed	4	2	0	4	10	0	3
Percentage having no opinion	0	4	10	3	0	0	4

rice on seaweed, rolling, and slicing). One Chinese family said that rice balls could not be made out of processed rice.

Summary

Two hundred Honolulu families, selected as a representative sample of the population, were interviewed before and after using processed rice.

A summary of the opinions on flavor, texture, and color of processed rice as compared to white rice and as compared to brown rice indicates that white rice is definitely preferred but that processed rice is more acceptable than brown. Color is a more important factor than flavor or texture in the preference for processed rice as compared with brown.

Twelve percent of the families preferred processed rice to brown or white, but only 3 percent preferred brown. Since most of these families were tasting processed rice for the first time, there is reason to believe that processed rice will be a more effective substitute for white rice than brown has been.

SUMMARY AND CONCLUSIONS

Factors affecting the nutritive value and use of processed rice in Hawaii have been studied.

Twenty-two samples of processed rice have been found to have an average thiamine content of 193 micrograms per 100 grams. Processed rice has higher thiamine, niacin, calcium, phosphorus, and iron contents than does white rice, but has lower thiamine and iron contents than does brown rice. Processed rice has a lower moisture content than brown or white.

During 16 weeks of storage in two Honolulu warehouses, processed rice was found to have slightly less insect infestation than white rice and much less than brown rice. During storage, the processed rice lost 17 percent of its thiamine content; brown rice lost 33 percent, and white rice 34 percent. Losses of niacin were less than those of thiamine—approximately 15 percent of the niacin content of all the rices.

The same rices stored 18 months under laboratory conditions also decreased in thiamine content. Processed rice lost 34 percent, brown rice 38 percent, and white rice 15 percent.

The thiamine of processed rice has been shown to be available to human beings by studies of the thiamine excretion of human subjects on a diet containing 375 grams of rice, raw weight, daily.

Washing processed rice seven times removes 22 percent of the thiamine and about 50 percent of the minerals. Washed processed rice contains an insignificant percentage of the daily requirement for calcium, phosphorus, and iron. Brown rice retains its nutrients better during washing than either white or processed.

Losses of thiamine in cooking processed rice vary according to the method used from 18 to 54 percent. Discarding the cooking water results in large losses of thiamine. Brown and white rice cooked in small amounts of water lose 18 and 9 percent of their thiamine content.

A study of plate waste in school cafeterias indicates that processed rice is eaten readily by customers of such cafeterias.

Interviews with 200 Honolulu families who tried the rice indicate that 12 percent of them prefer processed or mixed processed and white to other kinds of rice.

It may be concluded from these studies that processed rice stores as well as or better than white rice and has a higher nutritive value. It is lower in nutritive value than brown rice but is not as subject to insect infestation and deterioration.

To conserve nutrients, rice should be stored as short a time as possible; it should be washed only once or not at all; and it should be cooked in a small amount of water which is absorbed by the rice. One pound, raw weight, of properly cooked fresh processed rice can be expected to supply one-third of the daily recommended allowance of thiamine and phosphorus and all of the allowance of niacin.

Taking into consideration the many aspects of this study, summarized above, and the extensive use of rice in the Territory, there is reason to believe that processed rice may prove more acceptable than brown rice, and that the wider use of processed rice will result in improved dietaries of rice-eating peoples.

APPENDIX I
DESCRIPTION OF RICE SAMPLES

BROWN RICE

Sample 1. Ten pounds received direct from California mill. Short grain. Caloro variety. This sample was stored 1 year before being analyzed.

Samples 3, 4, 5, 6, 7, 8. Six 100-pound sacks received at the same time as samples 33 to 38 and 63 to 68 direct from California mill. Short grain. Caloro variety.

Sample 10. A 200-gram sample taken from large supply at University Cafeteria. Short grain. Variety unknown.

Sample 12. One 1-pound package received direct from Arkansas mill. Long grain. Nira variety. Samples 12, 42, and 72 received at the same time.

Sample 14. One 1-pound package received direct from Texas mill. Long grain. Rexoro variety. Samples 14, 44, and 74 received at the same time.

Sample 16. A composite sample from samples 3, 4, 5, 6, 7, 8, taken after 18 months' storage.

Sample 17. Ten-pound lot procured from a 100-pound sack of California rice at the University Cafeteria. It had been bought by Cafeteria 2 weeks before sampling. Variety unknown. Short grain.

Sample 18. One 100-pound sack from California. Stored 6 weeks before being analyzed. Variety unknown. Short grain.

WHITE RICE

Samples 33, 34, 35, 36, 37, 38. Six 100-pound sacks received at the same time as samples 3 to 8 and 63 to 68 direct from California mill. Short grain. Caloro variety.

Samples 40 and 41. Two 200-gram samples taken from large supply at University Cafeteria at two different times. Short grain. Variety unknown.

Sample 42. One 1-pound package received direct from Arkansas mill. Long grain. Nira variety. Samples 12, 42, and 72 received at the same time.

Sample 44. One 1-pound package received direct from Texas mill. Long grain. Rexoro variety. Samples 14, 44, and 74 received at the same time.

Samples 46 and 47. Two 5-pound packages purchased from two Honolulu groceries. Produced in California. Short grain.

PROCESSED RICE

Sample 61. Ten pounds received direct from California mill. From same lot as sample 1. Short grain. Caloro variety. This sample was stored 1 year before being analyzed.

Sample 62. One 100-pound sack received direct from California mill. Short grain. Caloro variety.

Samples 63, 64, 65, 66, 67, 68. Six 100-pound sacks received direct from California mill at the same time as samples 3 to 8 and 33 to 38. Short grain. Caloro variety.

Sample 72. One 1-pound package received direct from Arkansas mill. Long grain. Nira variety. Malek process. Samples 12, 42, and 72 received at the same time.

Sample 73. One 1-pound package received direct from Arkansas mill. Long grain. Fortuna variety. Malek process.

Sample 74. One 1-pound package received direct from Texas mill. Long grain. Rexoro variety. Conversion process. Samples 14, 44, and 74 received at the same time.

Sample 75. One 1-pound package received direct from Texas mill. Broken grains. Long grain. Rexoro variety. Conversion process.

Samples 76, 77, 78, 79, 80, 81, 82, 83. Purchased from different Honolulu groceries at different times. All in small packages, 1 or 2 pounds. All short grain. Variety unknown. Samples 76, 77, 78, 80, 81, 82, 83 from California. Sample 79 packed in Honolulu.

Sample 84. One 1-pound package received direct from California mill. From same lot as Sample 94, unhusked rice. Short grain. Caloro variety.

Samples 86 and 87. Two 2-pound packages received direct from Texas mill. Long grain. Variety unknown. Conversion process.

UNHUSKED RICE

Sample 94. One 1-pound package received direct from California mill. From same lot as Sample 84. Short grain.

APPENDIX II

METHODS OF COOKING PROCESSED RICE

Method 1. Boiled processed rice with gas or kerosene stove:*

Use one of the following proportions:

½ cup processed rice to ¾ cup water
or
1 cup processed rice to 1¼ cups water
or
2 cups processed rice to 2 cups water

For larger amounts of rice, use the same volume of water as of rice.

Do not wash rice, or wash only once. Add cold water to rice and bring to a boil. On gas stove boil rapidly for 2 minutes; then turn flame as low as possible and cook over low heat for 30 minutes. On kerosene stove boil rapidly for 5 minutes. Put asbestos pad under pan, turn flame down and cook over low heat 25 minutes.
Yield: 2½ cups for each cup of raw rice. Percentage thiamine retained: 71

Method 1 a. Boiled processed rice on electric stove:*

1 cup rice 2 cups water

Do not wash rice, or wash only once. Add cold water to rice, bring to a boil over high heat. Boil on high heat 10 minutes. Turn off heat and allow pan to remain on unit 10 minutes; stir well at the end of 5 minutes.
Yield: 3 cups

Method 1 b. Directions on package, samples 86 and 87:

Add 2¼ cups boiling water and 1 teaspoon salt to 1 cup rice. Cook in covered saucepan over low flame until the water has been absorbed (about 22 minutes).
Yield: 3⅓ cups Percentage thiamine retained: 79

Method 2. Processed rice cooked in double boiler (directions on package, samples 86 and 87):

Add 2¼ cups boiling water and 1 teaspoon salt to 1 cup rice in a double boiler. Cook in covered double boiler until water has been absorbed (about 35 minutes).
Yield: 3½ cups Percentage thiamine retained: 80

Method 3. Processed rice cooked in the oven:*

Place 1 cup rice in a baking dish, add 1 teaspoon salt and 2¼ cups boiling water. Cover tightly and bake at 400° F. for 45 minutes.
Yield: 3¼ cups Percentage thiamine retained: 82

Method 4. Processed rice cooked in the pressure saucepan:

1 cup rice ¾ cup water

Do not wash rice, or wash only once. Add cold water to rice in pressure saucepan. Bring to a boil. Apply pressure weight. After pressure is reached, cook 11 minutes. Turn off flame. As soon as pressure is reduced, open saucepan and stir rice vigorously.
Yield: 2 cups Percentage thiamine retained: 52
This method is not recommended because of the low thiamine retention and because the cooked product is not as light and fluffy as that prepared by boiling.

Method 5. Processed rice cooked in large amounts of water (directions on package, samples 76, 77, 78, 80, 81, 82, 83):

Bring 6 cups water to a boil in large saucepan. Slowly add 1½ teaspoons salt and 1 cup rice. Boil, covered, 25 to 35 minutes, decreasing heat last 10 minutes. Drain.
Yield: 3¼ cups Percentage thiamine retained: 46

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*Marked recipes were developed under the direction of Katherine Bazore Gruelle, Chairman, Department of Home Economics, University of Hawaii.

APPENDIX III

MENUS USED IN THE STUDY OF AVAILABILITY OF THIAMINE IN PROCESSED RICE

FIRST STUDY

Food	Amount	Micrograms thiamine
Typical day's menu on white rice diet		
Breakfast		
Rice	250 grams*	35
Banana	70 grams	33
Milk	¼ cup	7
Cream	2 tablespoons	10
Lunch		
Rice with	250 grams*	35
Tomato paste	1½ tablespoons	33
Milk	¾ cup	50
Cottage cheese	½ cup	20
Pickles	3 slices	0
Ripe olives	1	0
Green olives	1	0
Cream	1 tablespoon	5
Dinner		
Rice	250 grams*	35
Chicken	½ cup	9
Apricots	3	8
Pickles	3 slices	0
	Total	280
Sugar and butter ad libitum		
Typical day's menu on processed rice diet		
Breakfast		
Rice	350 grams*	129
Applesauce	½ cup	7
Cream	2 tablespoons	10
Lunch		
Rice	350 grams*	129
Bouillon	1 cup	1
Ripe olives	1	0
Green olives	1	0
Milk	1 cup	67
Dinner		
Rice	350 grams*	129
Pimiento	⅓ pimiento	3
Salmon	½ cup	7
Pickles	3 slices	0
Bananas	100 grams	47
	Total	529
Sugar and butter ad libitum		

*Cooked weight.

SECOND STUDY

Sample menu used for both white rice diet and processed rice diet

Calculated calories: 1895.

Food	Weight	White rice diet	Processed rice diet
	Grams	*Micrograms thiamine*	
Breakfast			
Papaya	100	24	24
Rice	125*	61	141
Cream	30	10	10
Lunch			
Rice	125*	61	141
Ham	25	257	257
Onion, green pepper, pimiento	20	6	6
Beets	60	7	7
Milk	120	34	34
Dinner			
Chicken	80	7	7
Rice	125*	61	141
Peas	100	161	161
Asparagus	75	35	35
Lettuce	10	8	8
Apricots	60	7	7
Milk	240	67	67
Total		806	1046
Sugar and butter ad libitum			

*Raw weight.

THIAMINE CONTENT OF FOODS USED IN THE DIETS
Analyses were done in this laboratory

	Micrograms thiamine per 100 grams
Canned goods	
Applesauce	7
Apricots, whole, peeled	5 to 12
Asparagus	47
Beets	11
Carrots	17
Chicken	8 to 9
Fruit cocktail	5 to 6
Green beans	25
Guava juice	0.5
Ham, whole, baked	571 to 1026
Olives, green, stuffed	4
Pickles, sweet, sliced	5
Pickles, sweet, whole	3
Pimiento	20
Salmon	20
Salmon, barbecued	7
Salmon, smoked	53
Sardines, smoked	1
Tomatoes	48
Tomato paste	167
Frozen foods	
Orange juice	70 to 74
Peas, cooked	161
Pineapple	55 to 67
Spinach, cooked	34
Fresh foods	
Bananas, apple	40
Bananas, Chinese	54
Beef rib roast	75 to 88
Beef rib roast, cooked	66 to 68
Cottage cheese	20
Cucumber	10 to 13
Daikon	41
Eggs	61 to 78
Ground round steak, cooked	96
Papaya	15
Pork sausage, cooked	587 to 616
Milk	26 to 29

APPENDIX IV

ANALYSIS OF SAMPLE OF POPULATION USED FOR INTERVIEW STUDY

TABLE A. Representative Sample of Population of Honolulu, Based on 1943 Office of Civilian Defense Census.

OCCUPATIONAL GROUP*	HAWAIIAN†	CAUCASIAN	CHINESE	FILIPINO	JAPANESE	OTHERS	TOTAL
1. Professional	2	9	2	0	3	0	16
2. Semi-professional	0	1	0	0	1	0	2
3. Farmers and farm mgrs.	0	0	0	0	2	0	2
4. Proprietors	1	9	3	0	6	1	20
5. Clerical	3	12	8	0	11	0	34
6. Craftsmen, foremen	3	8	3	1	11	1	27
7. Operatives	6	7	4	2	10	1	30
8. Domestics	1	1	1	0	10	0	13
9. Service workers	3	15	3	2	7	1	31
10. Farm laborers (wage workers)	0	0	0	0	1	0	1
11. Farm laborers (unpaid familyworkers)	0	0	0	0	2	0	2
12. Laborers	4	3	2	3	8	2	22
13. Not reported	0	0	0	0	0	0	0
Total	23	65	26	8	72	6	200

TABLE B. Analysis of Sample of 200 Interviews with Honolulu Families

OCCUPATIONAL GROUP*	HAWAIIAN†	CAUCASIAN	CHINESE	FILIPINO	JAPANESE	OTHERS	TOTAL
1. Professional	1	6	3	0	4	1	15
2. Semi-professional	0	0	0	1	1	1	3
3. Farmers and farm mgrs.	0	0	0	0	3	0	3
4. Proprietors	2	4	8	0	14	0	28
5. Clerical	1	6	12	0	10	2	31
6. Craftsmen, foremen	8	15	2	3	20	2	50
7. Operatives	7	7	4	2	11	2	33
8. Domestics	0	0	0	0	1	0	1
9. Service workers	0	5	1	2	4	2	14
10. Farm laborers (wage workers)	0	0	0	0	1	0	1
11. Farm laborers (unpaid family workers)	0	0	0	0	0	0	0
12. Laborers	4	1	0	2	6	2	15
13. Not reported	4	1	0	0	1	0	6
Total	27	45	30	10	76	12	200

*As classified in the Sixteenth Census of the U. S. (*62*).
†Includes Part-Hawaiian.

APPENDIX V

QUESTIONNAIRE USED IN THE INTERVIEW STUDY

INFORMATION NEEDED ON USE OF PROCESSED RICE:

Address of the family__________

How many people in the family? Adults?______ Children?______ Ages?______

What is the racial background of family?______ How many of the household are 1st generation?______

What are the occupations of the wage earners?______

- -

How many meals a week is rice used by family?______

At which meal was the processed rice served?______

How many people were at the meal when the processed rice was served?______

How many persons tasted the rice?______

How much raw processed rice was cooked?______

Was that enough to satisfy the family? Yes______ No______

How much, if any, was left over?______

Was more than usual left on plates? Yes______ No______

How much water was used to cook the processed rice?______

Was this the same as for ordinary rice?______

How long was the processed rice cooked?______

Was this the same as for ordinary rice?______

What was the cook's opinion of this rice as compared to white rice?

	Better	Same	Poorer
Texture	______	______	______
Color	______	______	______
Flavor	______	______	______

What was the cook's opinion of this rice as compared to brown rice?

	Better	Same	Poorer
Texture	______	______	______
Color	______	______	______
Flavor	______	______	______

What comments did the other members of the family make?______

____

____

Of the 3 kinds of rice which do the members of the family prefer?

Brown?______ Processed?______ White?______

Mixed brown and white?______ Mixed processed and white?______

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